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CHARACTERISTICS OF OPTICAL FIRE DETECTOR FALSE ALARM SOURCES AND QUALIFICATION TEST PROCEDURES TO PROVE IMMUNITY, PHASE II, VOLUME iii

WRIGHT LABORATORY

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This study identified possible sources of UV, IR and visible radiations that may cause an optical fire detector to false alarm and/or affect its fire detection performance. The spectral irradiances of JP-4 pan fires and a multitude of lamps, hot bodies, and other of radiation stimuli that an optical detector may be exposed to in any type of aircraft shelter, hanger, facility, or ground location, were determined. Knowing the spectral irradiances of the required fire size and distance to be detected, it was then possible to determine at what distances would the potential false alarm source have to be to equal or exceed the fire's spectral irradiances in the 185nm - 250nm and 4.4lm bands. Considering the possible distance from detector to source, candidate false alarm sources were selected for detector immunity testing. Qualification test procedures were developed and tested. It was concluded that there are many possible false alarm sources and, if located too close to a detector, and the stimuli are modulated, most optical fire detectors would alarm.

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PREFACE

This final report was prepared by Donmar Limited, 901 Dover Drive, Suite 120, Newport Beach, California 92660, under Contract F08635-91-C-0129, with Wright Laboratory, Fire Protection Section (WL/FIVCF), Tyndall AFB, FL 32403-5323.

The period of performance for this contract extended from April 8, 1991, through October 8, 1992. The WL/FIVCF Project Officer was Mr. Charles W. Risinger.

The authors wish to acknowledge the cooperation and assistance provided by Civil Engineering, Fire Department, Flight Test, and other department personnel at Edwards AFB in the conduct of the field measurements. Also, the authors thank the Fire Departments at Travis AFB, Beale AFB, Norton AFB, Hickam AFB, and Bitburg AFB for their assistance during this effort. The cooperation of the fire detector industry in this effort to increase fire detector reliability is also greatly appreciated.

This technical report was submitted as part of the Small Business Innovative Research (SBIR) Phase II Program and has been published according to SBIR Directives in the format in which it was submitted.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The objectives of this project were: (1) to determine the nature and properties of objects and phenomena that may cause an optical fire detector to false alarm and/or affect its ability to identify fire; and (2) to develop qualification test procedures to determine an optical fire detector's false alarm immunity.

B. BACKGROUND

It was assumed that the minimum detection threshold of a detector must be at least equal to the spectral irradiance from the specified type and size fire at its specified maximum distance from the detector. The fire type, size, and distance assumed herein for analysis was the standard Air Force specification of a 2-foot x 2-foot JP-4 panfire at a distance of 100' in 5 seconds or less (or a 1-foot x 1-foot at 50 feet). Spectral irradiance data were measured during controlled burns.

C. SCOPE

Consideration was given to both monospectral detectors (e.g. UV, IR, visible) and multispectral detectors (e.g. UV/IR and other combinations of the EM spectrum) in this study. The bands where most of these detectors operate are 185nm-250nm centered at about 220nm in the UV, and about 4.2μm-4.6μm centered at 4.4μm in the IR.

Possible false alarm sources were identified by analyzing past events, reviewing Air Force bases in the U.S. and Europe, discussing false alarm problems with detector manufacturers, and analyzing objects and phenomena that may exist in the field-of-view of a detector when used in various applications. Spectral irradiances were then determined by field measurements concentrated at Edwards AFB, laboratory measurements, and literature reviews. These spectral irradiances were then compared to the measured spectral irradiances in the same bands of the 2-foot x 2-foot JP-4 fire at 100 feet. Sources were selected that either individually or in combination had sufficient irradiances to satisfy what should be the minimum thresholds of an optical fire detector in its band(s) of operation. Manufacturers were asked to supply detectors set at the above threshold level. These were used to develop test procedures for the false alarm sources that may be found in any typical Air Force hangar, shelter, or facility. Distances between source(s) and detector were determined for practical applications.

D. CONCLUSION

It was concluded that many types of UV and/or IR sources can satisfy the minimum energy flux threshold of a fire detector commonly used in AF hangar and shelter applications. The nature

and properties of these sources were identified in great detail in this study. Moreover, although most detectors today use other features in their detection logic, such as modulation of the incoming IR signal or ratioing of two wavelengths, all these features can be and have been duplicated during routine aircraft-associated ground operations.

E. RECOMMENDATION

This study resulted in a recommendation of a set of test procedures that can be included in an RFP, a purchase description, or a specification to help assure that the detector(s) being purchased meet the reliability expectation of the government before delivery and installation.

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APPENDIX II

[SAMPLE OF A POSSIBLE MILITARY SPECIFICATION FOR

TEST PROCEDURES TO QUALIFY OPTICAL FIRE DETECTORS

FOR THEIR FALSE ALARM IMMUNITY]

METRIC
MIL-STD-XXX
OCTOBER 8, 1992

(PROPOSED FORMAT--EXAMPLE ONLY)

MILITARY SPECIFICATION

FIRE DETECTOR FALSE ALARM IMMUNITY QUALIFICATION TEST PROCEDURES

This (example) specification is approved for use within the US Air Force and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers (1) the types of sources or radiation emissions that may affect the performance of optical fire detectors in detecting fires and/or cause them to false alarm; and (2) recommended procedures to test the immunity of detectors to these nonfire radiation sources.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Mr. Charles Risinger, WL/FIVCF, Stop 37, 139 Barnes Drive, Ste. 2, Tyndall AFB, FL 32403-5323, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1.2 Objective. The objective of this specification is to increase the reliability of fire detectors and fire detection systems against false alarms and to assure the Air Force and any other Department of Defense agency or department that the fire detectors it procures are qualified to perform as required within the environment to which they would be exposed.

1.3 Background. Fire detectors are designed to respond to the presence of certain wavelengths of electromagnetic radiation that are emitted during combustion. However, several categories of nonfire sources of these same radiations may be present within close proximity to, and in the field-of-view (FOV) of, a detector. A detector may then be "fooled" by such nonfire sources as being fires, thus causing activations of alarms and/or releases of fire extinguishant when no fire exists. Such events can have serious impact upon military operations. It is a goal of the Air Force to eliminate the occurrence of false alarm events by certifying through tests the immunity of fire detectors to nonfire sources prior to their installation. Attainment of this goal will contribute to increasing the survivability of critical weapon systems and to minimizing deleterious impacts of false alarms on military operations.

1.4 Purpose. The purpose of this specification is to provide the performance basis for false alarm immunity of fire detectors operating in today's and tomorrow's complex aircraft operational environment and to meet the fire threats to which new and costly weapons systems are exposed. This specification is not intended to include optical fire detector (OFD) operational performance test procedures other than those directly associated with the potential false alarm sources listed herein. Although OFDs can be affected by certain induced environments, this specification does not require environmental testing. It recommends, however, the conduct of certain tests which follow MIL-STD-810, MIL-STD-461, and MIL-STD-462. It is the responsibility of the agency/department procuring the OFDs to specify performance, reliability, and other features.

1.5 Application. This specification pertains to (1) optical fire detectors (referred to herein as "OFD's") that are used in fire protection applications in aircraft hangars, shelters, maintenance facilities, ramps, runways, parking areas, fueling docks, and other aircraft-associated locations where fire detectors may be placed; and (2) nonfire sources of radiations that may exist either directly or indirectly within the fields-of-view (FOV) of such fire detectors.

1.6 Definitions. The following definitions and nomenclatures apply to this specification.

A. Fire Detector (OFD). A device that determines the presence of a fire by measuring one or more of its physical properties or associated effects. This includes devices that detect electromagnetic radiation emissions with wavelengths in the ultraviolet (UV), visible, or infrared (IR) portions of the electromagnetic spectrum. Such devices may function in one or more bands in the UV, IR, or visible, and may rely upon intensity threshold measurements, rate-of-change measurements, ratios between two or more intensity measurements at different wavelength regions, modulation of the radiation flux, or other means of discriminating fires. Nomenclature normally used to describe fire detectors covered in this specification include: Flame Detector, UV Detector, IR Detector, Heat Detector, Rate-of-rise Thermal Detector, UV/IR Detector, UV/UV Detector, IR/IR Detector, and combinations or multiples thereof. Smoke detectors are not covered by this specification.

B. Fire. The process of combustion in air of any hydrocarbon-based substance. For the application herein, fires will consist of aircraft fuels, such as JP-4, JP-8, or AV-A, hydraulic fluids, hydrazine-based fuels, and other hydrocarbon-based combustible materials that may be found in aircraft hangars, shelters, and aircraft-associated facilities/locations. In specifying fire detection performance, the fire event is referred to by size in terms of a square pan at some distance from the detector [e.g. 0.61 meters x 0.61 meters (2 feet x 2 feet) JP-4 pan fire at 100 feet distance].

C. False Alarm Source. Any physical phenomenon, device, process, tool, entity, or utility that emits, transmits, reflects, or directs electromagnetic radiations that may be detected or measured by a fire detector and cause it to signal "fire" when no fire exists, and/or affect a fire detector's reliability in detecting specified fire size at some distance in some elapsed time.

The term "false alarm source" is used throughout this specification to connote this general definition and not to imply that an object, entity, device, or phenomenon in itself will cause a detector to false alarm. The word "may" is emphasized.

For the application stated herein, possible false alarm sources are categorized as follows (several specific types of sources may exist within some categories).

CATEGORY 1. Lights (sources that emit in any spectral band of the UV, visible, or IR).

a. Fixed in-place lights for facility, hangar, shelter, runway, ramp, area, and building illumination.

b. Moving lights such as those on vehicles (fire trucks, security cars, ambulances, personnel carriers, towing trucks, and fuel trucks).

c. Photographic lights.

d. AGE (Aircraft Ground Equipment) area lighting carts ("Lightalls").

e. Aircraft lights such as landing, IFR, and collision avoidance lights.

f. Tools such as flashlights with colored lens covers.

g. Insect repellant lights (black lights).

CATEGORY 2. Reflected light (either UV, visible, or IR).

a. Reflected from colored objects, clothing, standing fluids, sand, ground, runway, glass, and polished metals, regardless of source.

CATEGORY 3. Natural Phenomena.

a. Sunlight.

b. Lightning.

CATEGORY 4. Electrical Arcing/Electrostatic Discharge.

a. High voltage arcing such as from power transformers, motors, faulty wiring, and electrical devices.

b. Electrostatic discharge to detector.

CATEGORY 5. Non-Destructive Investigative (NDI) Devices.

a. X-ray machines up to 300 KeV. Although OFDs do not operate in the x-ray region, certain types of detectors, such as UV vacuum tubes which operate as ionization counters, are directly affected. Also, certain solid-state electronics may be affected by x-rays.

CATEGORY 6. Electromagnetic Waves.

a. Portable radio communication devices such as "Walkie-Talkies", cellular phones, and remote telephones.

b. Aircraft tracking and navigation radar emissions.

c. Emissions from electronic switching power supplies and electronic equipment.

d. Emissions from aircraft subsystems such as communications jammers, decoys, and other weapon-system-associated items.

CATEGORY 7. Aircraft Engine Emissions (UV, visible, IR).

a. Any emission of UV, visible, or IR radiation from the engine exhaust during start-up, engine power settings through 80% (military), and during afterburner operation.

CATEGORY 8. Personnel Items.

a. Lit cigarette/cigar.

b. Matches (paper and wood).

c. Butane lighter.

CATEGORY 9. Tools/Operations.

a. Arc, TIG, and MIG welding operations.

b. Acetylene welding/cutting operations.

CATEGORY 10. Hot Bodies, Blackbody Radiators, Rapid Changes in Air Temperature.

a. Hot manifolds, exhausts, radiators, mufflers, and engines of all types of vehicles.

b. Hot manifolds, exhausts, radiators, and mufflers on AGE (aircraft ground equipments).

c. Thermal treating blankets.

d. Aircraft heaters/blowers.

e. Aircraft brakes, engine nozzles, pods.

f. Radiation heaters (1.5 KW and 1.0 KW with fan).

g. Radiation kerosene heater, 70,000 BTU, with fan.

h. Hot lights, lamps, welding materials (included in Categories 1 and 9).

CATEGORY 11. Security/Military Personnel Weapons.

CATEGORY 12. Fire/Explosive Events Associated with Aircraft and AGE Engine Wet Starts/Backfires.

These sources and modulators of UV, visible, and IR radiations, either by themselves or in combinations of two or more, may be causes of false alarms to some detectors. Testing therefore, for OFD false alarm immunity to the presence of these radiation stimuli either individually or in multiples, is required.

1.7 APPROACH. This specification identifies the many types of sources of UV, visible, IR, and electromagnetic radiations that may affect a fire detector, regardless of the type, application, or mode of operation. In this listing of possible false alarm sources, certain sources are predominant in their energy output, radiance flux, and spectral band. These predominant sources are the ones included in the recommended false alarm immunity test procedures. For instance, when two or more types of a source are present (e.g. 40 W, 100 W and 150 W frosted bulbs), that have the same spectral characteristics, the one which has the greater energy output is selected for test purposes (the 150 W bulb). However, the spectral energy outputs of whatever number of the same type of lamps are present are additive and the OFD "sees" this integrated irradiance. Therefore, although the higher energy output lamp may be used for the tests, it would be located at a distance which emulates the integrated spectral irradiance as seen by the detector.

If, however, a lower energy output type of source has a different spectral emission characteristic than the higher energy output type, then both types of sources are used in the tests.

1.8 Units. Symbols, units, and physical constants used in this specification are in accordance with the International System of Units (SI), as described in MIL-STD-463.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards and handbooks. The following specifications, standards and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto.

SPECIFICATIONS

Military

MIL-S-62546A(AT) - 11 Aug 1989		Sensor, Fire, Optical; US Army Tank-Automotive Command.

STANDARDS

MILITARY

MIL-STD-461	-	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
MIL-STD-462	-	Electromagnetic Interference Characteristics, Measurements of.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.

HANDBOOKS

MILITARY

MIL-HDBK-217	-	Reliability Prediction of Electronic Equipment.

2.1.2 Drawings and publications.

PUBLICATIONS (TECHNICAL LETTERS)

MILITARY

ETL-90-09 Nov 1990	-	Engineering Criteria for Aircraft 2 Maintenance, Servicing, and Storage Facilities; USAF, Directorate of Engineering and Services, Installation Development Division, Engineering Branch.

ETL 1110-3-411 - 26 Apr 1990	Design and Construction of Foam Fire Protection Systems to Protect Aircraft in Hangars; US Army Corps of Engineers, Engineering Division, Directorate of Military Programs.

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Fire detectors furnished under this specification shall be products which satisfy the specific requirements stated herein and required by the procuring agency.

4. UTILIZATION OF THIS SPECIFICATION

4.1 Department of Defense. This specification may be used by the Air Force or any other department or agency of the Department of Defense to select those tests to be conducted by the detector supplier which correspond to the specific false alarm sources that will be present in the fire protection application (i.e. facility, hangar, shelter, etc.). The applicable false alarm source immunity tests would then be included as "requirements" in purchase descriptions, requests for proposals, or contract documents, thus assuring the government that the detectors conform to reliability and performance requirements.

Other uses of the specification include: (1) determining restrictions, if any, on the conduct of certain operations or the presence of certain types of possible false alarm sources in the immediate location of the fire detection system; (2) determining the operational requirements of the fire detection system when certain false alarm sources may be present (e.g., although not recommended, it may be necessary to turn off the fire detection system when certain types of operations or sources are present); (3) determining the requirements on the fire protection system to meet the fire threat scenarios; and (4) designing aircraft related facilities and operations.

4.2 Detector Manufacturer. Detector manufacturers can use this specification to test and increase their detector's false alarm immunity performance against the sources included herein. The specification may be helpful in designing new detector concepts and/or in solving new applications problems. The information herein may also serve as a reference source for R&D and testing.

5. RESPONSIBILITY FOR SPECIFYING PERFORMANCE REQUIREMENTS.

The Air Force procurement agency, or the agency/department authorized by the Department of Defense to procure the fire protection system, specifies the detection system performance requirements, system configuration, and reliability. The detector manufacturer (supplier) designs and qualifies detectors and systems that satisfy the requirements, and submits proposals or quotations in response to bid invitations and requests for proposals.

6. ASSUMPTIONS AND EXPLANATIONS

6.1 Detector performance specification. Depending upon their application, detector performance specifications may vary, for example, from detecting a 61 cm x 61 cm (2 feet x 2 feet) JP-4 (or other fuel) pan fire at a distance of 30.5 meters (100 feet) in 5 or less seconds, to either more sensitive or less sensitive detection thresholds. This specification does not assume any fire detection threshold performance and, therefore, is applicable to all applications. In general, although not ipso facto, as a fire detector's threshold is decreased (sensitivity increased) to detect less amounts of radiation, it becomes more susceptible to being affected by the presence of nonfire radiation sources and, therefore, to false alarming. This specification therefore includes many sources of UV, visible, and IR radiations that may not have any independent effect upon most hangar detector applications, but may have effect upon other applications where higher sensitivity settings may be required.

6.2 Detector "system" specification. This specification does not consider the "system" operation in detecting fires and executing fire extinguishing actions. Rather, the specification is concerned with the individual detector unit. System configurations which provide overlap FOV ("footprint") coverage by 2 or more detectors, voting of 2 or more detectors' responses, zoning of two or more detectors, and other approaches to increasing mission success reliability are not included herein. Such system concepts are usually specified by the procurement agency and pertain to a special fire detection application. Should a purchase description and/or RFP specify system performance specifications for fire detection as well as for false alarm immunity, the individual detectors should still be tested for their false alarm immunity to both the single and multiple sources of nonfire stimuli described herein.

The assumption herein is that an individual detector should be immune to all nonfire false alarm sources that may be present in the application environment. Methods of increasing fire detection reliability through a "system" design requirement is not part of this specification.

6.3 Selection of possible false alarm sources. A fire detector measures the energy in distinct spectral bands which is incident over the area of its sensing elements. The sensing element(s) are selected to detect radiation only in regions that correspond to the characteristics of the fire's emissions and which are least confused with "background" radiation such as from the sun. Specificity and high signal-to-noise ratios are then design goals of optical fire detectors.

Once the detector's (or system's) performance specification is selected by the user (procurement) agency for the type and size of fire and its distance from the detector(s), the spectral irradiance of the fire at the maximum specified detection distance can be determined for the spectral bands of interest. This assumes, however, that the spectral radiance or irradiance at some distance is known for the fire type and size and that the atmospheric transmittance is also known. Knowing the fire's irradiance at the specified maximum detection distance determines which false alarm sources at what distances could contribute to false alarms. This, of course, also assumes that irradiances are known in the spectral bands of interest for those sources of radiation stimuli that may be located in the OFD's FOV.

For example, assume the purchase specification calls for a dual wavelength UV and IR detector, and that a 61 cm x 61 cm (2 ft x 2 ft) square pan fire of JP-4 fuel must be detected at a distance of at least 30.5 meters (100 ft). The irradiance of the fire at this distance in a narrow band, say 0.7 μm centered at 4.38 μm, is approximately 26 x 10^{-6} W/cm^2. In the UV the irradiance in the band 190 nm to about 250 nm is about 1.4 x 10^{-4} microwatts/cm^2 .

It should be pointed out that the irradiances can vary depending upon many factors including atmospheric humidity and dust, and winds. Given these two values of UV and IR irradiances in the bands of detector sensitivity, one can determine the distances of those nonfire sources having the same or greater spectral irradiances than those from the specified fire at its specified distance. This implies that any possible source of UV radiation in the wavelength band of 190 nm - 260 nm, with irradiances equal to or greater than 1.4 x 10^{-4} microwatts/cm^2 (this is the largest measured JP-4 2' x 2' pan fire irradiance at 100 feet) at any location within the OFD's FOV, qualifies as a source to which the detector must be immune. On the other hand, the lower range of the irradiance value in this same wavelength band for the same fire size and distance is 4 x 10^{-5} μW/cm^2, thus extending the range of possible UV false alarm sources.

For comparison purposes a 1 Kw QTH lamp at a distance of 15 meters (100 ft) has an irradiance in this UV band of about 2.8 x 10^{-4} microwatts/cm^2 (considering atmospheric absorption), two times more UV energy in this band than the 2 ft x 2 ft JP-4 pan fire at the

same distance, or a 1' x 1' JP-4 pan fire at 50 ft. A 450 W Xe lamp, for example, at 50 feet distance has an irradiance of about 5×10^{-4} microwatts/cm^2 (with atmospheric absorption considered).

However, assuming the minimum irradiance value of 4×10^{-5} microwatts/cm^2 for the same fire size and distance, any nonfire source posing this lower threshold irradiance may also be a false alarm source. The range then, could be quite large.

The analogy between intensity levels of UV emitters with respect to the response of a UV detector is not a straight-forward exercise. Time of response of the detector is a characteristic that must be considered in UV detection. Most UV detectors are ionization counters and "count" the number of conductions per unit time caused by the interaction of a photon striking the detector's cathode. A very small UV emitter can then trigger a UV OFD if the integration time of the detector is long, say 5 seconds. UV sources, therefore, that are much less in irradiance than the specified fire size/distance-detection specification, must be considered in selecting potential false alarm candidates.

Assuming that the infrared detector operates in the 4.4 μm area, any possible source of IR radiation in a narrow wavelength band centered near 4.4 μm with an irradiance equal to or greater than 26 microwatts/cm^2 at any location within the OFD's FOV, qualifies as a source to which the detector should be tested for immunity (assuming the specified fire size for detection is 2' x 2' at 100' or a 1' x 1' at 50'). Knowing a potential false alarm source's radiance (or irradiance at some distance as a function of wavelength) and the closest possible distance of the source from the OFD, the source's irradiance at that distance can be calculated and compared to the specified fire's irradiance at its threshold detection distance.

6.4 Distances of false alarm sources from detectors. The false alarm immunity specifications herein list minimum distances of possible false alarm sources from an OFD. The stated distances reflect real-life situations or possibilities which are based upon examination of Air Force bases in Europe, the Pacific, and continental United States. In most locations, where "under-the-wing" aircraft fire detection is required, detectors are mounted on a facility, hangar, or shelter wall at a minimum height of 2.4 meters (8 ft) to about 3.05 meters (10 feet) above the floor. However, in other facilities, hangars, and shelters the height above the floor may extend to near the ceiling. Most OFDs have 80 - 90 degrees fields-of-view (FOV). In some situations, such as TAB V Shelters Series 1-3, the walls are not vertical but arched (near hemispherical). There may also be other applications where detectors can be located only a meter or so above the ground, or mounted on a mobile platform. Therefore, there are no objective criteria on which to unequivocally estimate all detector heights

and therefore distances from possible false alarm sources.

Because it is impractical to list specific distances for detector immunity for each and every possible application, the distances stated herein are presumed to be worst case situations that, if used for qualification testing, would cover all possible applications. In most cases the sources recommended for detector immunity testing were selected by determining their approximate irradiances at the closest possible location to the OFD, as discussed in paragraph 6.3. However, it is the final responsibility of the procuring agency to specify the distances and to cite deviations from this specification.

It should be pointed out that the irradiance of a fire varies depending upon atmospheric conditions such as wind, humidity, and dust. The irradiance may vary by a factor of 2-5 or so depending upon the burn conditions. This fire irradiance difference could make a large difference in the effective distance a false alarm source may have to be from the detector. For instance, the 190 nm - 250 nm irradiance at 100 feet may vary between 1.4×10^{-4} $\mu W/cm^2$ and 4×10^{-5} $\mu W/cm^2$. The corresponding "maximum" distances of a possible false alarm source, for example a 300 W QTH lamp, with these same irradiances would be 35' and 58' respectively. This implies that the lower the irradiance value of the specified fire the greater the distance of the threat of a false alarm source.

6.5 <u>Variations, alterations, and methods of false alarm source operations</u>. Radiation stimuli from possible false alarm sources may experience temporal, spatial, and/or spectral variations due to the influence of nonfire related events or phenomena, or to how the source is operated. The variations included in the test procedures herein take into account other similar military quality assurance and reliability testing procedures of optical fire detectors and electronic devices and systems.

The test procedures will require certain operations to be performed either directly on a particular source or indirectly on a source's radiation emission properties. For instance, it may be required in some tests to turn the source's power on and off a number of consecutive times or to intermittently interrupt the source's radiation "beam". Some light sources have a "start-up" phase involving UV emission and "flicker" that may satisfy the "flicker" frequency requirements of the detector. Regardless of location, emitted or reflected radiations can also be "chopped" by moving vehicles, fans, and personnel moving through the beam between the source and the detector, and even wind-driven ripples on standing water puddles. This random or fixed frequency of varying the beam intensity may appear to a detector as fire radiation "flicker".

6.6 Simulation. Where appropriate, certain properties of possible false alarm sources may be simulated by utilizing one or more near-identical characteristics inherent in other devices or objects. As an example, it may be impractical to directly test a detector's response to an F-15 aircraft engine's exhaust. There are several approaches however, to simulating the ultraviolet, visible, and infrared emissions during engine power levels through afterburner operation.

Also, it may not be practical to directly test a detector's response to various types of hot body radiators such as found on aircraft ground equipment (AGE) engine exhausts/manifolds, aircraft engine nozzles, and high power light sources. Rather, by heating certain types of materials or heating elements to appropriate temperature levels, the blackbody emission curves from these objects can be simulated.

Many of the potential false alarm sources are high intensity lamps of up to 1500 Watts, and even greater for some photographic flood lamps. Some of these lamps require special fixtures and power supplies, and may be expensive. It is possible on some lamp types to substitute a lessor wattage lamp, but to test it at closer distances than the called-for higher wattage false alarm source. The important criterion is that the spectral irradiance should be equivalent to that found in the application. This may be accomplished by calculating the required distance of the smaller lamp from the OFD to equal the irradiance of the larger lamp at its specified distance in the test procedures. Tables and graphs of spectral irradiances and radiances of many types of lamps called out herein for testing can be found in reference 1 (Optical Radiation Emissions from Selected Sources, Part I. Quartz Halogen and Fluorescent Lamps, U. S. Food and Drug Administration, Department of Health and Human Services, Publication FDA 81-8136, dated October, 1980; and Part II. High Intensity Discharge Lamps, HHS Publication FDA 85-8236, dated November 1984). From these data, using the inverse square law, and applying atmospheric correction where feasible, the distance can be determined at which the irradiance of the substitute smaller wattage lamp equals the irradiance of the called-for larger wattage lamp at the greater distance.

The simulation procedures included herein represent possible techniques to accomplish the test requirements. They are not mandatory per se. The detector supplier may have a more efficient and less costly technique that satisfies the temporal, spatial, and spectral energy emission (or reflection) properties of the potential false alarm source.

6.7 Detector exposure to multiple false alarm sources. There are situations when a number of different categories (and types) of possible false alarm sources may exist within the field-of-view of a detector. The distances of each source may vary depending upon

their nature, operation, and application.

This specification covers the exposure to single sources (one-at-a-time) and to multiple sources (combinations of two or more sources at the same time). The selection of combinations of multiple false alarm sources and their respective distances from an OFD, is based upon actual situations where the presence of such sources is consistent with the nature and operations associated with fire-protected areas, structures, and weapon systems. In cases where some uncertainty existed in selecting the types of sources and configurations to be included in tests, a conservative approach was taken.

The procuring agency may specify single or multiple combinations of sources for immunity testing that pertain to the particular fire protection application of interest.

6.8 Differences of false alarm sources on military bases. The military may use different types of sources of UV, IR, and visible radiations for the same application. For instance, the aircraft shelters at an Air Force base in Germany may use fluorescent lights, while shelters on a base in England may use both fluorescent and mercury vapor. Also, different types of aircraft, with different types of engines and subsystems, can occupy a particular facility/area at any particular time. This requires a fire detector (and possibly fire detection system) to be immune to the emissions from many types of aircraft engine exhausts and on-board subsystems that may be activated on the ground.

This specification takes into consideration these possibilities and attempts to list a broad-based distribution of the many types of sources (especially lights) that may be found throughout military base locations.

6.9 Electromagnetic wave false alarm sources. In addition to nonfire sources of UV, IR, and visible radiation, there are other sources of electromagnetic (EM) radiation that may cause a fire detector to false alarm. These sources constitute Category 6 as described in Section 1.6 C. EM fields associated with communications systems, attack radars, terrain following radars, weapons systems, electronic countermeasure jammers, and other aircraft related items, may affect the electronics of detectors and cause them to malfunction. Previous OFD response tests on aircraft electromagnetic emissions indicated sensitivity to certain power levels of attack and terrain following radars.

This specification does not include any specific fire detector immunity tests for such EM emissions, other than immunity tests against a standard 5 watt hand-held Walkie-Talkie radio. The procurement agency may elect however, to require fire detector immunity against EM emission sources, possibly because of the planned location of the OFD and/or the types of aircraft and

aircraft operations that will occur within the FOV of the OFD. Should this requirement be imposed, MIL-STD-461C and MIL-STD-462C may be specified. It is advisable that these standards be integrated into the design features of any detector that may be used in the DoD.

The category would be A1c, Aerospace Ground Equipment Associated with Aircraft, Including Electronic Support Equipment. The following paragraphs/tests described in Part 2, MIL-STD-461C, would be required unless the detector manufacturer can verify via other methods or past qualifications that its detector(s) pass these tests: CS02; CS06; RS02; RS03; and tests CS03, CS04, CS07, CS11, and RS05 (limits are included, but may be changed by the procurement agency, depending upon the OFD application). These tests all pertain to susceptibility; no emission tests would be applicable to an OFD's false alarm immunity.

The above tests should be conducted via the test procedures stated in MIL-STD-462C."

6.10 Detector malfunctions/false alarms due to induced environments. Fire detectors and their associated control electronics may be susceptible to induced environments such as extreme temperatures, water immersion, shock, vibration, humidity, and atmospheric pressure. False alarms and false dumps of extinguishants have occurred due to aircraft engine-induced vibrations, water leakage, and other environmental causes.

These environmental-associated causes are not included herein as false alarm sources, as they are normally included in performance specifications related to reliability. However, because they can cause detector false alarms and failures, the procurement agency may elect to require fire detectors to satisfy the environmental testing requirements of MIL-STD-810D, "Environmental Test Methods." This test requirement is standard on all military hardware procurements associated in any manner with a weapon system. Should this requirement be imposed, the following recommended tests would cover the environments to which fire detectors may be exposed at Air Force base locations. The detector must continue to operate according to specifications during and after the following tests, except where noted. The user may specify different values than those stated below.

A. Section 501.1 High Temperature: The high temperature requirement shall be 60 degrees C (140 degrees F).

In addition to the high temperature requirement, rapid changes in air temperature should also be included herein. Rapid removal of a thermal blanket or the "sweep" of an aircraft engine exhaust through the area where the detector is located can affect the infrared OFD's response. A test for this case is included in paragraphs 8.1.1.1.8 and 8.1.1.1.11.2.

B. Section 502.2 Low Temperature: The low temperature requirement shall be -48 degrees C (-55 degrees F).

C. Section 512.2 Leakage (Water Immersion): Per the stipulations of this section. These tests should also include a water jet test. This test should be conducted with the OFD operating. A water jet should be applied at right angles to front and side surfaces of the OFD from a distance of 2 meters. The jet shall be derived from a nozzle having an orifice diameter of not more than 6 mm (0.25 in) and a nozzle pressure of 345 +/- 105 Kpa (50 +/- 15 psi).

D. Section 511.2 Explosive Atmosphere: Test per the stipulations and procedures of this section. Any equipments such as warning devices (alarms) that have been certified via the manufacturer to pass this test are not required to be re-tested.

E. Section 516.3 Shock (guideline): The detector must be able to withstand the following shock without being mechanically damaged or false alarming. The detector, and associated subsystems, should be mounted in accordance with this test. The detector must operate normally after these tests.

"After 3 shocks in each of 3 planes of 500g +/- 50g of 0.5 ms duration (or shock with the same energy content) the detector, and associated subsystems, must operate in accordance with the operating data, without false alarming."

"After 10 shocks of 10g +/- 1g of 60 ms duration in each plane the detector, and associated subsystems, must operate in accordance with the operating data, without false alarming."

F. Section 514.3 Vibration: Use the criteria for ground vehicles mobile, Category 8 of the standard. The tests should be conducted in all three planes with the detector mounted as required in the specific application. During the following tests, the detector shall not malfunction or false alarm.

In addition to these vibration tests, the detector shall undergo functional test levels approximating jet-noise-induced vibration (do not test for aerodynamical flow-induced vibration), thus simulating the vibration inside a hangar/shelter due to jet engines. The levels to be tested are described in MIL-Std-810D table 514.3-III and figures 514.3-26 and 514.3-27. The detector shall operate according to specification during <u>all</u> these vibration tests, including engine-induced vibration.

G. Section 500.2 Altitude: The detector and associated subsystems must function correctly at sea level pressure and must survive an altitude of 15,000 meters (49,200 feet).

H. Section 510.2 Sand and Dust: Per the stipulations of this section.

7. OPERATIONAL PERFORMANCE REQUIREMENTS OF FIRE DETECTORS

7.1 Immunity to single and multiple sources. The procurement agency shall specify the fire detection capabilities and properties of the OFD and/or fire detection system. This performance specification will also include the requirement that the OFD shall not signal the presence of a fire due to the influence of any one or combination of two or more nonfire sources of radiation stimuli, as proven via the test procedures specified herein. The procurement agency may specify which sources and tests are applicable to the specific procurement application.

7.2 Ability to detect/discriminate fire in presence of single or multiple false alarm sources. In addition to being immune to false alarm sources, an OFD must be capable of performing its mission in detecting fire of the specified type, size, distance/location, time, and field-of-view (FOV) while in the presence of the specified types and variations of false alarm source(s). Included herein are required test procedures to demonstrate such OFD fire detection capabilities.

In general, an OFD installed in aircraft maintenance, servicing, and storage facilities shall detect the following fires while in the presence of one or more of the false alarm sources stated herein: "The OFD shall detect a JP-4 fuel pan fire 3.05 meters by 3.05 meters (10 feet by 10 feet) in size at a minimum distance of 45.7 meters (150 feet) within 5 seconds, and a 61 cm by 61 cm (2 feet by 2 feet) JP-4 pan fire at a distance of 30.5 meters (100 feet) within 5 seconds." The procuring agency may also specify the potential condition of the cleanliness of the OFD lens as part of this performance requirement.

7.3 "Real fire events" that may cause unwanted activations of alarms and/or extinguishant systems. Although not considered false alarm sources, explosive and/or fast expanding, short-lived fire events occasionally occur in aircraft shelters, hangars, and maintenance facilities. These events are associated with "backfires"/"wet-starts" involving aircraft engines, APUs, jet fuel starters, and AGE equipments. These events are caused by accumulation of unignited fuels from unsuccessful attempts at starting the engine. On a subsequent attempt, the fuel-rich mixture is ignited, resulting in a fire ball/protruding flame.

Engine starts are accomplished with either the APU, jet engine fuel starter (JFS), or black cartridge starter (not commonly used today). The JFS is a "miniature jet engine" located in the front section of the engine. Once started it provides the necessary air flow to turn the main engine while fuel is being injected. Should

the engine not start on the first or second attempt, unspent fuel remains. This build-up of fuel is eventually ignited, resulting in an explosive fire event accompanied by flame exiting the gas vent, exhaust nozzle and/or the engine nacelle open access door. Other small fire events associated with the nacelle area can occur due to JFS failures and hydraulic and fuel line leaks. If allowed to progress, however, these events can escalate to three dimensional fires which also involve leaking fuels/fluid to the floor.

In both cases of aircraft and AGE items, a small hydrocarbon fireball and/or short lived flame occurs. The fireball events are short lived, typically about 2 seconds or less. Their sizes range from 1000-3000 cm^2 (1-3 ft^2). The exiting flame from the gas vent on fighter aircraft is typically about 50 cm in length. In most cases these events either burn themselves out or are extinguished by the ground crew. However, they can become major problems if not suppressed during their early phases. They should, therefore, be detected early by the OFD (or system). However, if the suppressant system is automatically activated before the fire becomes a real threat, military operations may be disrupted.

On some aircraft the flame protruding from the APU gas vent may produce an IR irradiance at 4 meters distance, in a 0.7 μm band centered at 4.38 μm, of about 2 Mw/cm^2.

The procurement agency shall specify the detection/suppression performance requirements that are unique to the application. However, for most applications the OFD should not respond with a fire suppressant system activation signal at the early explosive fireball phase of the event, but should alarm to the presence of any resulting fire provided its size meets the minimum size threshold specified by the procurement agency. If the fire event grows to some minimum specified size, within some specified time period, the OFD may also be required to automatically activate the suppressant system.

8. OFD FALSE ALARM SUSCEPTIBILITY TO SINGLE SOURCES

8.1 OFD response. The OFD shall not respond with a signal representing the presence of "fire" due to the radiation stimuli from single/independent sources (or several of the identical sources) indicated in the following paragraphs and tables during any of the tests prescribed herein. Also, during the tests herein, the OFD shall be able to detect the threshold size fire at the prescribed distance and time as specified by the procurement agency.

8.1.1 Immunity tests of radiation stimuli. The OFD shall not respond at distances equal to or greater than the specified immunity distance when exposed to the radiation sources listed in table 1 (and/or other tables and figures included herein)

throughout the FOV of the OFD specified by the procurement agency. This requirement shall be met with the OFD (or system) on, source turned on and off; source on, OFD turned on and off; chopped light (radiation), as specified herein. Table 1 is a listing of those objects and phenomena, and their respective minimum distances, which the purchasing and/or user agency has determined to be possible false alarm sources. The detector must therefore be tested for its response to these sources according to the test procedures and distances specified by the purchasing and/or user agency.

Table 1. Required Single Source Qualification Tests: Potential False Alarm Sources, Distances, and Test Procedures
(table to be completed by respective purchasing/user agency)

This table will differ according to the application, location of the detectors, planned configuration of the facility and its internal distribution of UV, IR and visible radiation sources, and the planned operations within the facility.

8.1.1.1 <u>Test configuration, methods, documentation and certification</u>. In order to conform to the requirements stated in 8.1 herein, the OFD shall be arranged in the configuration indicated in each recommended test procedure. Manufacturer's recommendations on detector setup/mounting, including wiring, conduit entry sealing, and other factors should be followed in preparing the tests herein.

The methods used in conducting the tests shall follow standard test procedures and include thorough documentation, notes, diagrams, raw test data, and reduced and analyzed test data. The detector manufacturer will be required to submit certifications or non-conformance statements to these tests. The document shall be concise and include six sections and a summary certification.

A summary of test results (conclusions) and a statement of certification and/or "exceptions" to each test requirement shall be included in Section 1. This section shall contain a table listing vertically the paragraph number herein pertaining to each test required by the procurement agency. In columns across the top of the table shall be the following subjects: PASSED COMPLETE TEST AS REQUIRED; FAILED PARTS OF TEST (EXPLAIN ON SEPARATE PAGE); FAILED TEST (EXPLAIN ON SEPARATE PAGE); DID NOT PERFORM TEST (STATE REASON ON SEPARATE PAGE); CLAIM PASSED BY SIMILARITY (EXPLAIN ON SEPARATE PAGE). Check marks shall be made in the appropriate column for each test, and explanations provided where required. This section shall also contain the following statement, signed by the person responsible for the tests results.

Table 1

REQUIRED SINGLE SOURCE QUALIFICATION TESTS

SOURCE/DESCRIPTION	REQUIRED TESTS/ PARAGRAPHS	DISTANCE FROM DETECTOR

THIS TABLE IS TO BE COMPLETED BY THE DETECTOR PURCHASING AGENCY OR THE USER AGENCY RESPONSIBLE FOR THE SPECIFICATION

"I hereby certify that the tests required by _______________ ___________________________(state name of procurement agency), with respect to the specification included in document_________________________________ ____(state document title and/or reference number), were conducted according to stated procedural requirements, or alternative methods described herein, with exceptions noted herein, and that the results stated in the summary table and explained elsewhere in this document are true to the best of my knowledge."

Signed:____________________date____________________

Section 2 shall describe the nature of the test and describe each and every source tested. Section 3 shall describe the test setup and the test equipments and any calibrations. Section 4 shall describe each step taken in the performance of the test. Section 5 shall include test data and any related comments, notes, tables, and graphs. Section 6 shall list the person(s) who conducted the tests along with the dates and places of the tests.

8.1.1.1.1 Chopped radiation stimuli tests. All of the sources of radiation stimuli shall be tested in a "chopped" mode, unless stated otherwise. The test procedure shall be as follows for single/independent sources (presence of only one source at a time). Note that the location of the chopper wheel with respect to the detector face is a worst case situation, because the chopping action covers the entire FOV of the detector. In some tests the chopped radiation test requires the chopper apparatus to be located near the source, not the OFD,

Step 1. A scalloped wheel or fan apparatus shall be used for chopped light tests. The "blades" of the devices shall be made of a highly reflecting material such as polished aluminum. The apparatus shall be driven by a variable power motor and shall be adjustable to incremental speeds of 0.5-, 1-, 3-, 5-, 7-, 10-, 15-, 20- and 25 cycles per second. The apparatus may be used for chopped radiation tests either directly in front of the OFD or in the cone of emission in front of the emitting source(s). Figure 1 is a representative drawing of the apparatus and the test configuration.

Step 2. The apparatus (fan) shall be placed 10 cm (or whatever is required in the test) directly in front of the OFD in such a position as to not obstruct any of the radiation flux other than by the "blade" that will interrupt the beam for the prescribed range of frequencies.

Step 3. The length of each test at each specified frequency shall be at least 30 seconds unless stated otherwise.

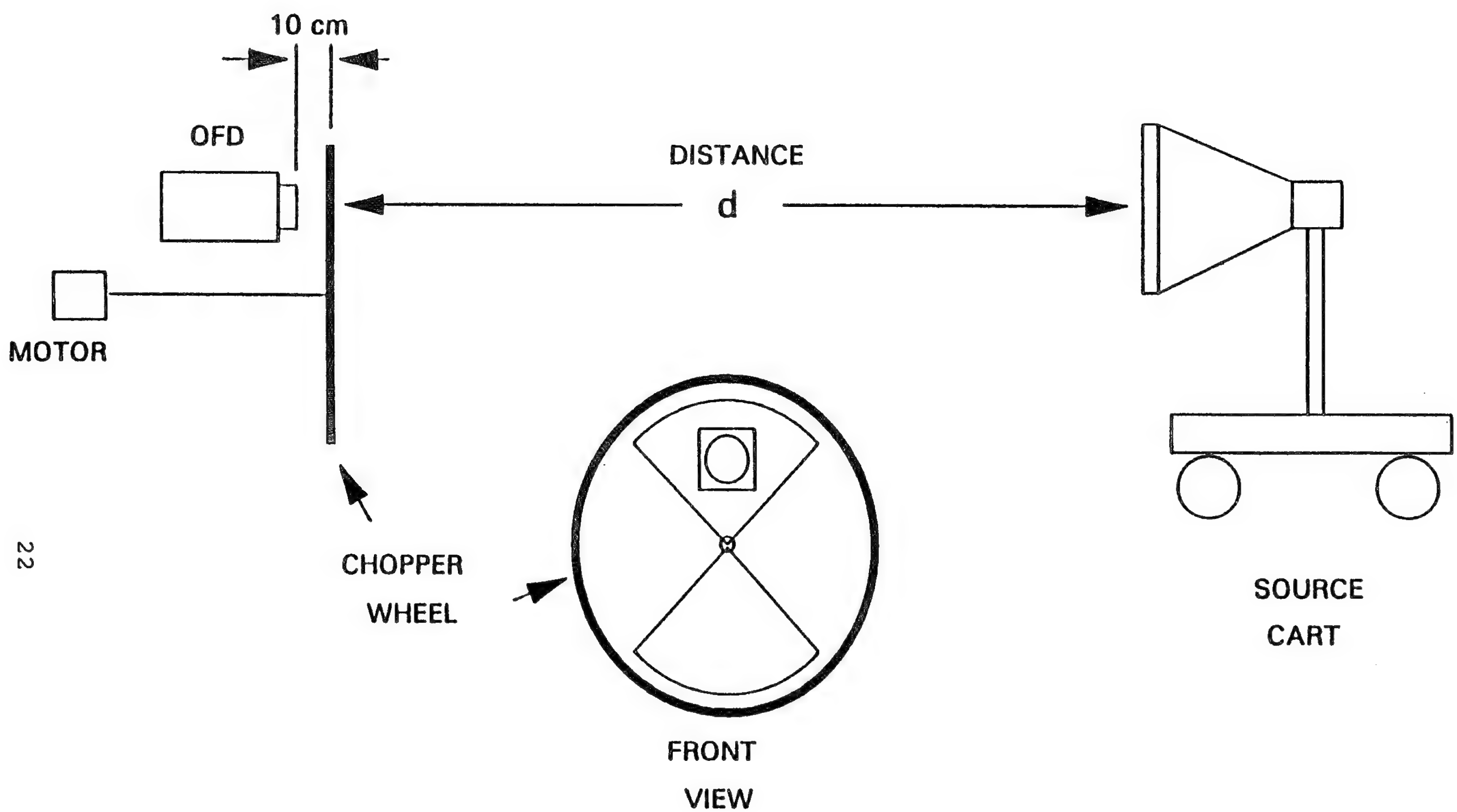


Figure 1, Refer 8.1.1.1.1
CHOPPED RADIATION STIMULI TEST CONFIGURATION

The OFD shall not respond with a fire signal during any test. Also, during and immediately after the tests, the OFD shall be able to detect the specified size fire at the specified distance and time. Tests to prove this performance are not included herein, although they may be required by the procurement agency as part of its purchase description or specification.

8.1.1.1.2 Test procedures for Category I sources-"Lights". A multitude of different categories and types of lights may be found at Air Force base locations. Also, different types of lights may be used by bases for the same application. The main body of the final report and Appendix I contain listings of light categories and types and their individual characteristics and properties.

8.1.1.1.2.1 Fixed-in-place area, utility, facility lights. Table 1 includes the various lights/lamps that the purchasing and/or user agency has specified will be present in this application, as well as their expected distances from the detector(s). The specific lights included in the following tests, have unique spectral emission characteristics or operating features. Some have selective narrow band emissions in the UV. Some may exhibit a random radiation output during start-up. Some produce large heat output. Some may require glass cover plates to absorb the UV and to provide safety protection from possible explosion. Some are gas discharge; some fluorescent; some incandescent; some colored; some very intense. All the lights listed in table 1 shall be tested individually according to the following procedures. The user/purchasing agency shall stipulate which lights are to be included in the false alarm source testing.

See Table 1. Lights Requiring Immunity Testing

(to be completed by the purchasing and/or user agency)

Step 1. The lamp shall be mounted approximately 1.5 meters above the floor or any reflecting surface. The OFD shall be mounted at the same height. The lamp and OFD shall be separated the distance specified in table 1. A representative test fixture arrangement is shown in figure 2.

Step 2. After the OFD has been on for 30 minutes, the light, with its respective lens cover plate on, if applicable, shall be turned on and left on for 30 minutes.

Step 3. After 30 minutes of lamp operation, the lamp shall be moved back and forth five (5) times, 45 degrees on either side of its original center line axis. The rate of movement shall be

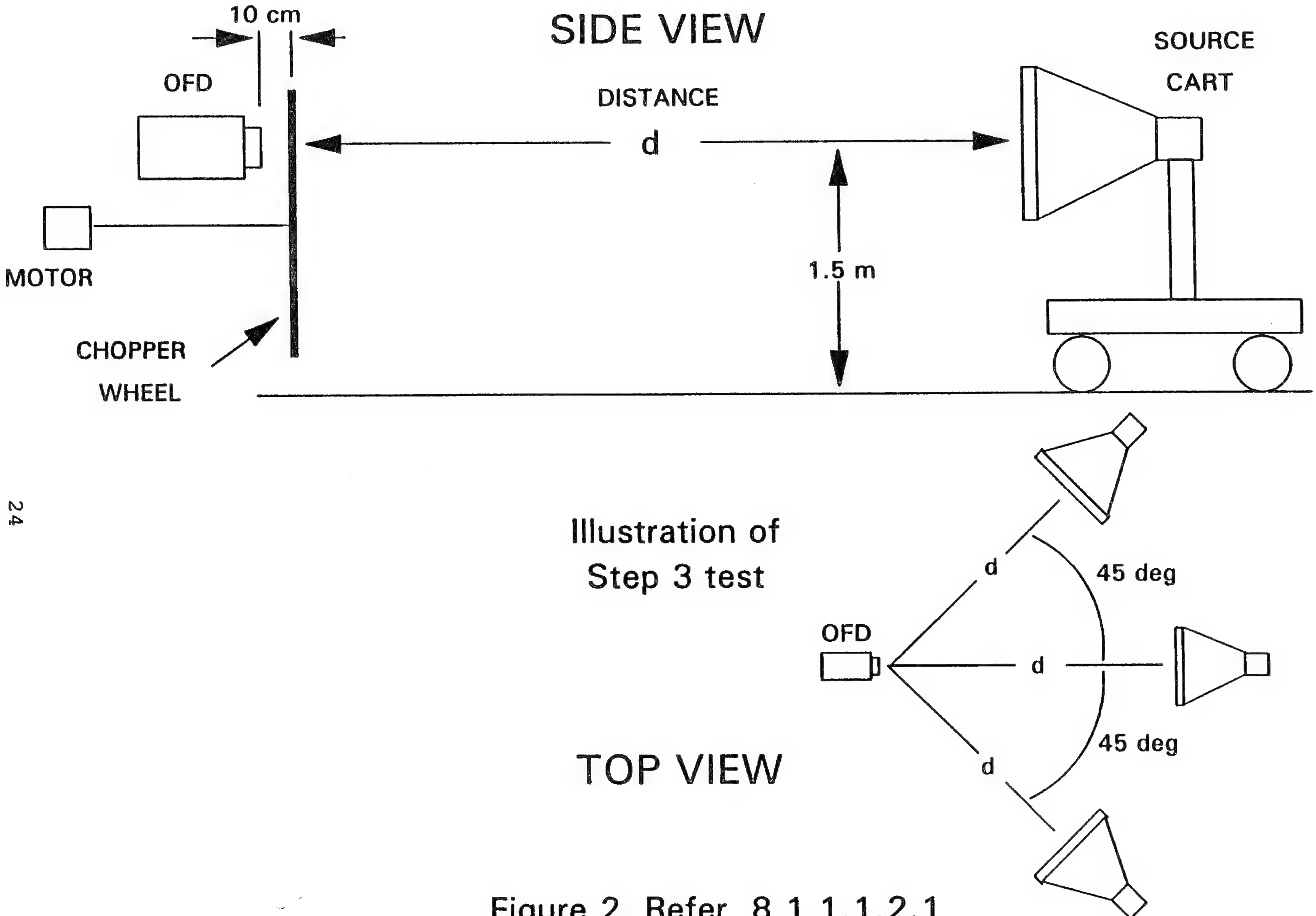


Figure 2, Refer 8.1.1.1.2.1

FIXED-IN-PLACE AREA, UTILITY AND FACILITY LIGHTS

approximately 45 degrees/2 seconds.

Step 4. Immediately following step 3, with the light and OFD directly facing each other, the OFD shall be switched on and off 5 consecutive times at intervals of 1 second. With the OFD on for at least 10 minutes, the light shall then be switched on and off 5 consecutive times at intervals of 5 minutes (or the time required for cooling down between starts/restarts).

Step 5. The chopped radiation test described in 8.1.1.1.1 shall be conducted with the chopper located directly in front of the OFD (about 10 cm away) so as to occupy the entire FOV of the OFD. The frequencies and times of operation are stated in 8.1.1.1.1.

Step 6. The above tests shall be repeated with the respective lamp's glass cover plate removed.

Step 7. The above six steps shall be repeated three times.

During the entire test procedure, the OFD shall not provide a fire alarm output/signal.

8.1.1.1.2.2 Moving vehicle lights. The following types of vehicles are included in this category: fire trucks, fuel trucks, ambulances, security cars, personnel carriers, tugs, trucks, and other general purpose vehicles. These vehicles have one or more of the following types of lights: (1) headlamps conforming to MS53023-1, e.g. GE 4811; (2) tail/stop lights; (3) spot light; (4) red dome light conforming to MS51073-1; (5) red rotating beacon, e.g. GE 7400R; (6) IR light conforming to MS53024-1; (7) blue-green dome light conforming to MS51073-1; and (8) strobe lights red/clear. Each of these lights shall be tested according to the following procedures.

Step 1. The test configuration is shown in figure 3A. As indicated, the light fixture is to be easily movable. The light fixture shall be located 10 meters (33 ft) from the OFD, with the light facing directly at the OFD. After at least 30 minutes OFD operating time, the light shall be turned on and manually moved directly toward the OFD at a slow speed of 30-60 cm/second, and stopped at a distance of 1.5 meters from the OFD.

Step 2. At a distance of 1.5 meters from the OFD, the light shall be turned on and off 5 times at a switching interval of 1 second on, 1 second off.

Step 3. The light shall then be left on and moved backwards to its original location at a speed of about 30 cm/second (0.5 ft/second).

Step 4. The light apparatus shall be located 3 meters to the side of the OFD, 2 meters in front of the OFD (see figure 3 B). The

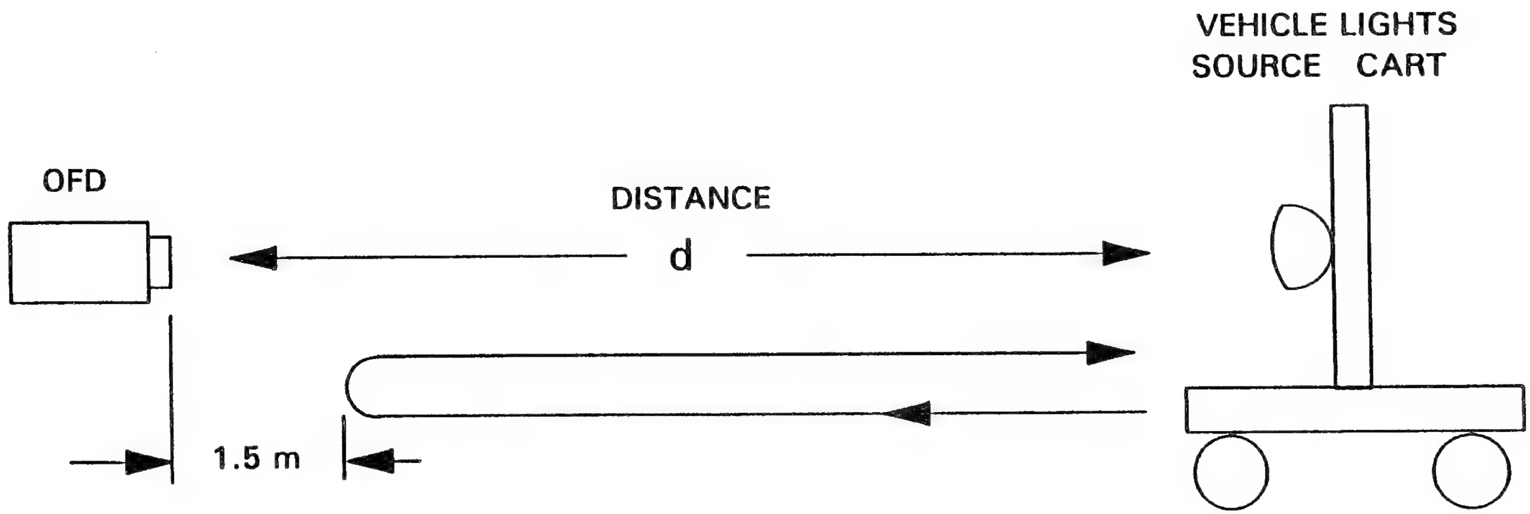
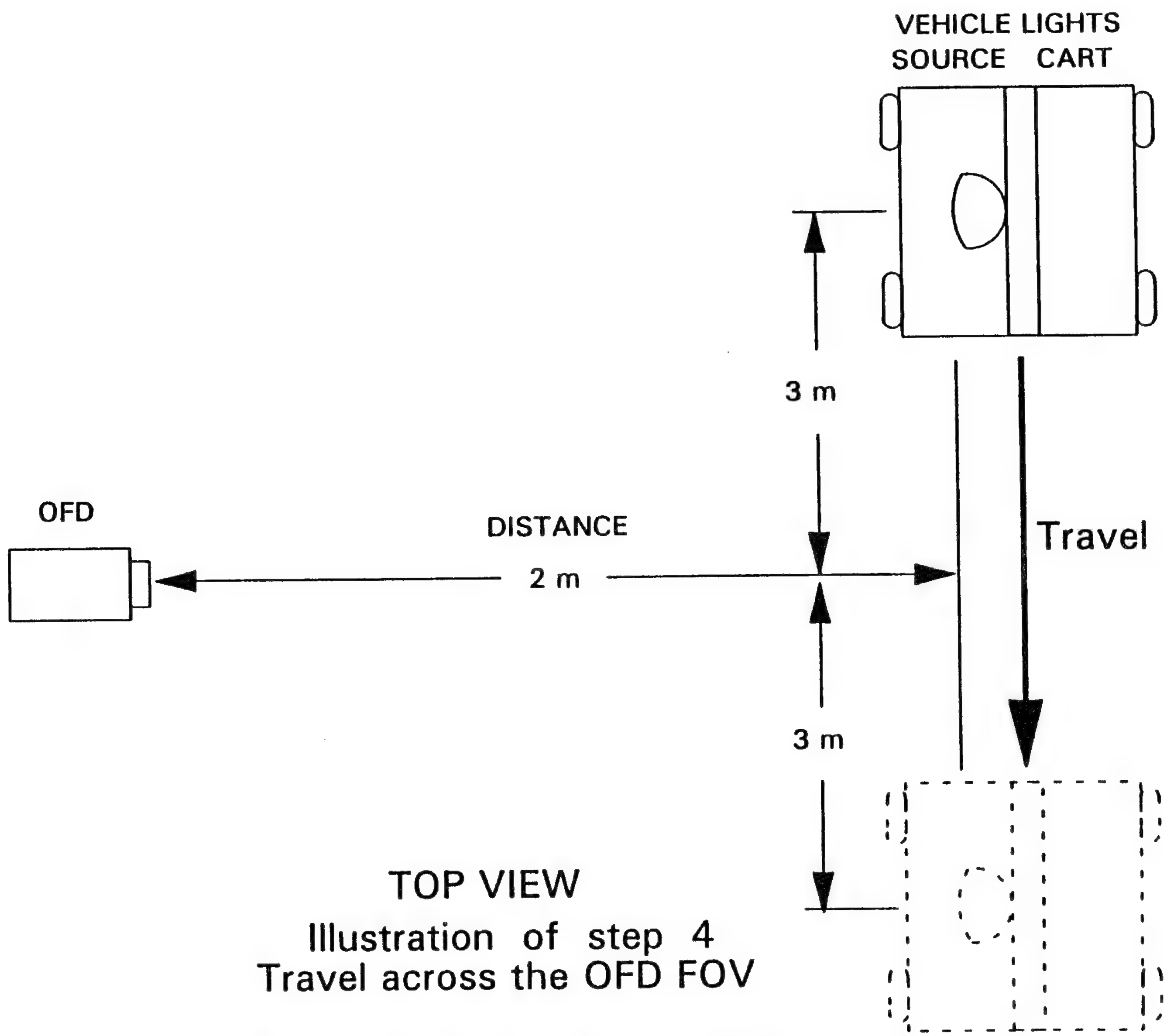


Illustration of steps 1,2 & 3
Travel toward and away from OFD

Figure 3A, Refer 8.1.1.1.2.2
MOVING VEHICLE LIGHTS TEST CONFIGURATION



TOP VIEW
Illustration of step 4
Travel across the OFD FOV

Figure 3B, Refer 8.1.1.1.2.2
MOVING VEHICLE LIGHTS TEST CONFIGURATION

light shall be moved 90 degrees across the OFD's FOV at a speed of about 15 cm/second until it is 3 meters (10 ft) past the OFD.

Step 5. Each test shall be repeated twice.

During these tests, the OFD shall not respond with a fire signal or be unable to detect the specified threshold fire under the conditions stipulated by the procurement agency.

8.1.1.1.2.3 Photographic lights. Objects and operations may be photographed within the immediate vicinity of an OFD. The flash and flood lights required during such photo sessions may emit radiations in spectral bands that could possibly be detected by an OFD. The following are examples of photographic lights and accessories that are employed at most AF bases. (1) Norman series 900 electronic flash systems: P4000-PS power supply with lampheads LH 4000 standard FQ-4 uncoated bulb, 4000 W-sec, 5900 degrees K effective temperature blackbody; Norman 200B, LH2, flashlamp, 200 W sec; (2) Metz 60 CT-4, flashlamp with window, 160 W, variable power, VAR W sec, auto ranging; (3) Vivitar 285 HB Strobe, 125 W sec, concentrated beam, F.P.; (4) Norman 2000B Strobe, 2000 W sec, 250 W sec standby; (5) Norman P500-M, series 450, 500-sec W, with 250 W modeling lamps; (6) Colortran 1000, quartz halogen flood, 1000 W, 250v; (7) EKI international motion picture projector lamp, 250 W; (8) Kodak EKTIGRAF 3, ATS projector lamp, 250 W, 50v; and (9) 3M overhead projector lamp ENX 350 W. The following test procedures include the light sources that produce the greatest intensity levels within their spectral emission bands. Although a specific lamp may be called out, any lamp of similar characteristics may be substituted.

Step 1. The OFD shall be mounted approximately 1.5 meters above the floor.

Step 2. On a separate fixture mount the following lamps or their equivalents: a 1000 W quartz halogen flood lamp; a Norman LH4000, 4000 W-sec 4Q-4, without UV correction, lamphead; a motion projector lamp; a 250 W QH modeling lamp (Norman Q250CL/DC); and an overhead projector lamp. Mount the lamps approximately 1.5 m above the floor. Place the lamp fixture 3 meters (10 feet) directly in front of the OFD. Two series 900 P4000-PS power supplies may be required if other power is not available.

Step 3. After the OFD has been on for 10 minutes, turn on the flood lamp and 250 QH modeling lamp.

Step 4. After 30 minutes, with OFD and flood and modeling lamps still on, switch the OFD on and off 5 consecutive times at intervals of 1 sec. Keep the OFD and two quartz halogen lamps turned on.

Step 5. Turn power on to the Norman LH4000 lamp (both flood lamp modeling lamp are still on). Operate the flashlamp at 2000 W-sec per flash at 3.5 sec recycle time between flashes and a flash duration of 1/240 sec for 2 minutes; operate again at 4000 W-sec per flash at 5 sec recycle time between flashes at 1/240 sec flash duration, 5 sec flash recycle time for two minutes.

Step 6. Operate the flood lamp, movie lamp, and projector lamp at the same time. After 10 minutes switch OFD on and off 5 consecutive times at intervals of 1 sec.

Step 7. Place the chopper apparatus in front of the OFD. Turn on modeling, flood, and overhead projector lamps. Operate the chopper according to paragraph 8.1.1.1.1.

Step 8. If any of the lamp fixtures have glass cover plates, remove them and repeat the steps.

Step 9. Repeat these steps twice.

8.1.1.1.2.4 AGE "lightalls". "Lightalls" (portable flood light sets) are a class of aircraft ground equipment used for area lighting. They are employed in a multitude of applications, including inside and outside illumination. Lightalls are multiple sources of UV-visible (multiple lamps) and infrared (hot body radiators associated with the engine). The multiple source tests are included in paragraph 9.1.1.2.4. The following tests relate to the lightall lamps only.

There are three basic lightall types found on most AF bases, namely, a two lamp cart (e.g., NSN 6230 877 9172) referred to as NF2, a new two lamp replacement cart (NSN 6230-01-276-6776) referred to as NF2D, and a four lamp cart (e.g., NSN 6230 01096-3508) referred to as TF-1. The TF-1 is normally used for runway and remote construction lighting and is not used for inside illumination unless special approval is obtained. The NF2 and NF2D units are used for various purposes and could be brought into or at the entrance to a facility/hangar if required. Each are shown in figures 4 and 5 respectively.

The NF2 uses two 400 W mercury vapor lamps, NSN 6240-00-885-6852, Phillips H33GL-400/DX, which have glass lens covers. The new NF2D uses two high pressure sodium 1000 W, GE HLXG0151A17X7XX059 or replacement part 88101357-1, with glass cover plates (NSN numbers have not been assigned as of the date of this specification). The larger lightall, TF-1, uses four 1000 W multivapor metal halide lamps, NSN 6240-01-012-0829, GE MVR 1000/U, which may have glass cover plates. It is possible that either lightall may have a glass lens that is either cracked, has a small hole, or is missing. Tests must account for these possibilities.

Figure 4. Lightall NF2 Aircraft Ground Equipment

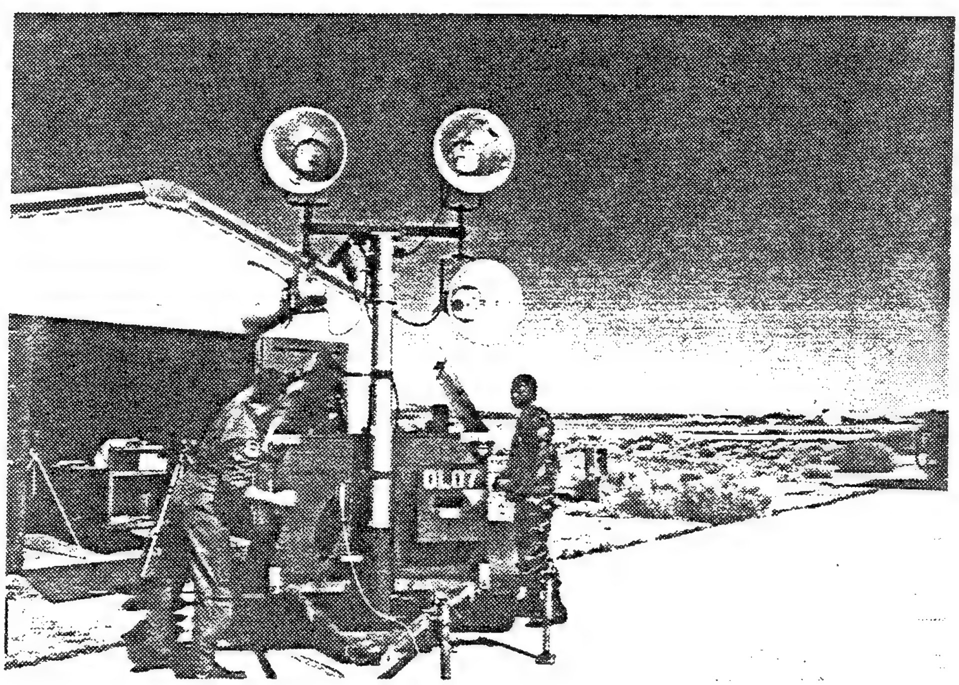


Figure 5. Lightall TF-1 Aircraft Ground Equipment

The spectral emissions of these lamps with or without glass lens cover plates, are summarized in Appendix I. The detector manufacturer may substitute other sources for the lamps specified herein providing they have equivalent properties and spectral emissions. Not only must the ultraviolet and visible spectral radiance flux properties be simulated, but also the temperature of the exposed glass surface (either the cover plate or the glass bulb enclosure envelope).

The first lamp is the 400 W mercury vapor lamp (NSN 6240-00-885-6852/Phillips H33GL-400/DX) used on the NF2 AGE unit. Figure 4 shows the lamp configuration on the unit. Each lamp is then about 183 cm (6 ft) above the floor. The closest distance to an OFD, mounted a minimum height of 2.4 meters (8 ft) above the floor, is about 1.5 meters (5 ft), considering the closest possible distance of the unit to the wall. The following tests incorporate only one lamp. See figure 6.

<u>Step 1.</u> The OFD shall be mounted 1.5 meters (5 ft) above the floor. On a separate fixture, one Phillips H33GL-400/DX lamp, with glass lens fixture plate on, shall be mounted 1.5 meters above the floor. The lamp shall be positioned 1 m from the OFD, directly facing the OFD (radiance of one lamp at 1 meter is equivalent to two identical lamps at 1.5 meters).

<u>Step 2.</u> The lamp shall be turned on for 30 minutes before turning on the OFD. After 30 minutes exposure has occurred, the OFD shall be turned on and off 5 times at intervals 1 second each. After this OFD switching test, the OFD shall be left on and the lamp turned on and off 5 times at intervals of 5 minutes each (5 minutes on, 5 minutes off).

<u>Step 3.</u> In the same configuration as in step 1 (distance and height), the chopper apparatus described in paragraph 8.1.1.1.1 herein shall be placed at a distance of 30 cm directly in the line-of-sight between the OFD and lamp. Both OFD and lamp shall be turned on and left on for 30 minutes. The chopper shall then be operated at 0.5-, 1-, 3-, 5, 7, 10-, 15-, 20-, and 25 Hz, respectively, for a period of 30 seconds at each setting.

<u>Step 4.</u> The lamp fixture shall then be slowly moved backwards at a slow rate away from the detector to a distance of 4 meters. It shall then be brought forward at a slow rate until it reaches 0.5 meters from the detector.

<u>Step 5.</u> The 1000 W high pressure sodium lamp on the NF2D lightall shall be tested in the same manner (steps 1-3) as the NF2 400 W mercury vapor lamp.

<u>Step 6.</u> The above tests shall be repeated without the glass lens cover plates on the lamps.

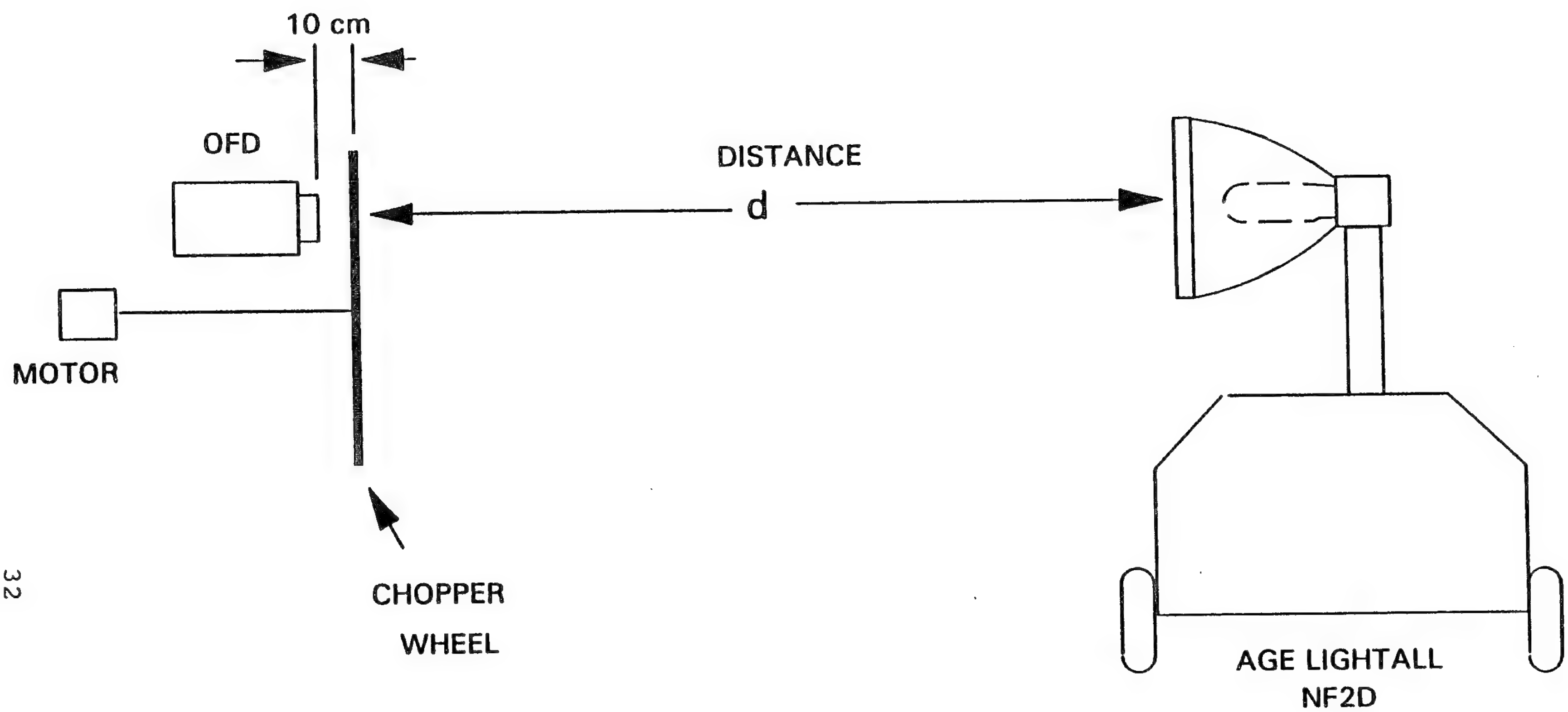


Figure 6, Refer 8.1.1.1.2.4
LIGHTALL, MODEL NF2D TEST CONFIGURATION

Step 7. The above tests shall be repeated twice.

The OFD shall not respond with a fire signal during any of these tests. Its ability to detect a threshold fire as specified by the procurement agency shall not be impaired. A test to verify this performance will be specified by the procurement agency according to their fire detection specifications.

The TF-1 lightall lamp test involves the 1000 W multivapor metal halide lamp, GE MVR 1000/U. Four lamps, mounted at the corners of a 1.2 x 1.2 meter square area, are affixed to a telescoping arm that can position the lamps (see figure 5) about 5 meters above the ground. Each lamp can be rotated 360 degrees and be moved in the vertical +/- 45 degrees from horizontal. It is assumed that this lightall will not be located inside any relatively small Air Force facility and that its closest distance will be outside at the opening of a hangar/shelter door, pointed 90 degrees across the door opening. Assuming the smallest shelter facility to be a TAB V, the closest distance from OFD to a TF-1 is about 15 meters (50 ft). However, in a large-body aircraft hangar facility such a light source could be located near the walls. It is assumed that the closest distance this AGE item would be placed from a detector would be about 5 meters (about 15 feet). We assume 15 feet as the test distance. See figure 7.

Step 8. One 1000 W multivapor metal halide lamp, NSN 6240-01-012-0829/GE MVR 1000/U, with its glass cover plate on, shall be located 1.5 meters (5 feet) in front of an OFD (the radiance at about 5 feet distance from one lamp is approximately equal to that from the four lamps on the TF-1 at 15 feet distance). Both the OFD and lamp shall be positioned at the same height above the floor (approximately 120 cm). After the lamp has been on for 30 minutes, the OFD shall be turned on.

Step 9. After 30 minutes exposure time, the OFD shall be turned on and off 5 times at intervals of 1 second. Immediately after this switching test, the OFD shall be turned on and the lamp turned on and off 5 consecutive times at intervals of 5 minutes (5 minutes on, 5 minutes off).

Step 10. After these tests are completed, the chopper apparatus shall be positioned 1 meter in front of the OFD. The lamp shall be left on for 30 minutes before the OFD is turned on. The chopper shall then be operated at frequencies and times specified in paragraph 8.1.1.1.1 herein.

Step 11. The lamp shall then be moved slowly backwards to a distance of 5 meters from the detector, and then brought slowly forward to a distance of 1 meter from the detector.

Step 12. Each of the above steps 8-11 shall be repeated with glass lens cover plates removed.

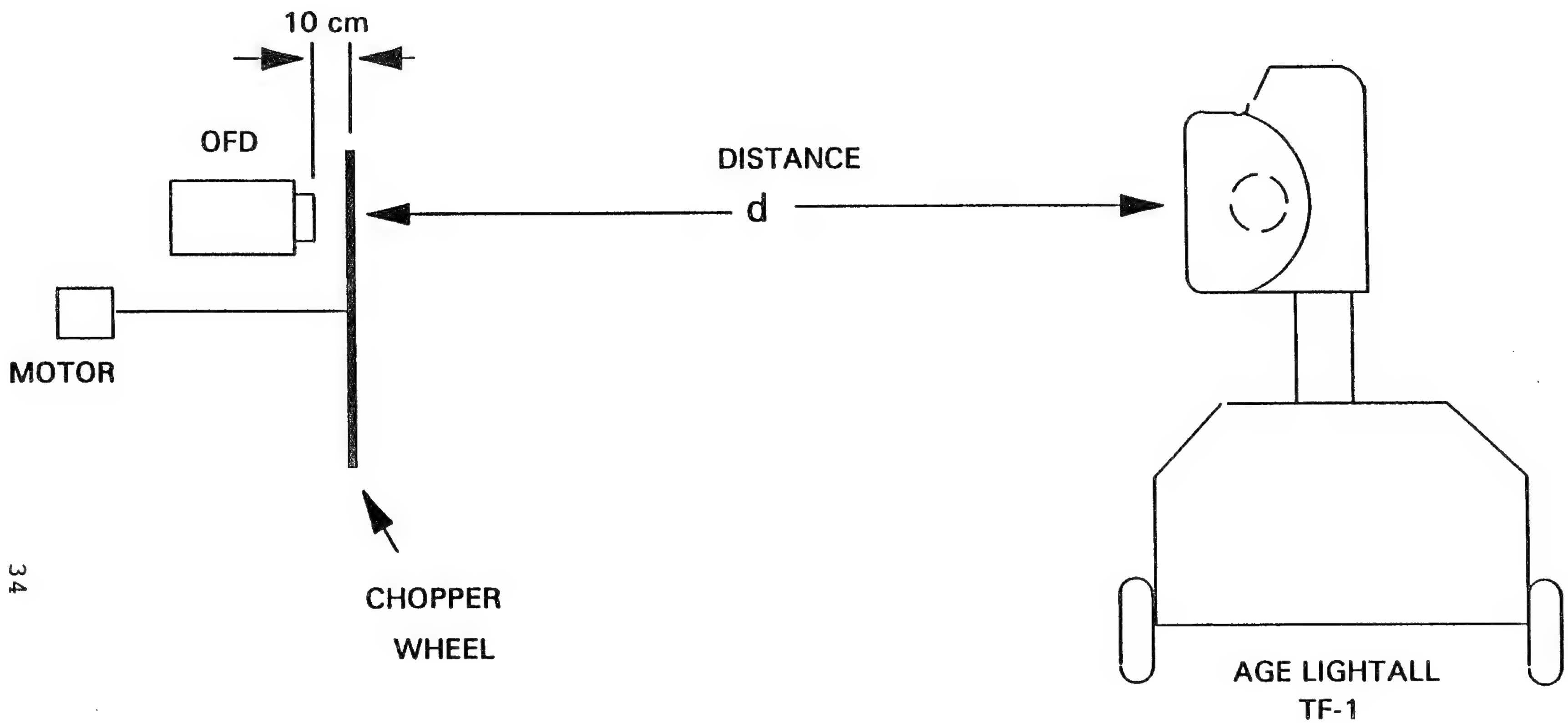


Figure 7, Refer 8.1.1.1.2.4
LIGHTALL, MODEL TF-1 TEST CONFIGURATION

Step 13. Each test 8-12 shall be repeated twice.

During these tests, the OFD shall not respond with a fire signal, and its ability to detect the threshold fire as specified by the procurement agency shall not be impaired. The procurement agency will specify this fire detection test.

8.1.1.1.2.5 Aircraft lights. Aircraft lights include a wide variety of different sizes and intensities. There are several types of lights, including anti-collision, navigation, landing, inflight refueling, parking, recognition, taxiing, and floodlight. These lights are all sealed beam incandescent. The landing light category contains the most intense light sources, ranging up to 750,000 candle power. The landing lights are of the quartz tungsten halogen (QTH) type and range up to 600 W. The spectral irradiance, for example, of a 600 W QTH lamp at a wavelength of 250 nm is about 1.2×10^{-4} microwatts cm^{-2} nm^{-1} at 7.5 meters (25 feet) distance. This can be compared to the radiant intensity in the band from 190 nm to about 250 nm from a 1 ft x 1 ft JP-4 pan fire at 15 meters (about 50 feet) of about 1.3×10^{-4} microwatts cm^{-2} nm^{-1}.

8.1.1.1.2.6 Tools-lights. Included in this category are simple handheld and/or portable devices such as flashlights, table lamps, extension lamps, infrared lamps, and inspection lamps. The lamps are incandescent and do not exceed 250 W.

8.1.1.1.2.6.1 Flashlight.

Step 1. A flashlight in accordance with MIL-F-3747, type I, style 2-2 cell (MX 991/U; or MX993/U) and the batteries shall be in accordance with MIL-B-18/9 (BA-30), shall be placed 10 cm directly in front of the OFD in such a manner that the light beam hits the center of the OFD lens, straight-on, and remains focused at this location.

Step 2. After 10 minutes, the flashlight shall be turned on and off three consecutive times at intervals of 5 seconds on, 5 seconds off. The flashlight shall then remain turned on while the OFD is turned on and off three consecutive times at intervals of 5 seconds on, 5 seconds off.

Step 3. At a distance of 10 cm from the OFD, the flashlight shall be moved (flickered) rapidly (0.1 second to either side) side-to-side, across the OFD's face.

Step 4. These tests shall then be repeated using a red lens over the clear lens.

Step 5. These tests shall be repeated twice.

The OFD shall not respond with a fire signal during these tests.

8.1.1.1.2.6.2 Electrical powered hand inspection light.

Step 1. A hand-held electrical 300 W quartz halogen light shall be placed 10 cm directly in front of the OFD in such a manner that the light beam hits the center of the OFD lens.

Step 2. After 10 minutes, the light shall be turned on and off three consecutive times at intervals of 5 seconds on, 5 seconds off. The light shall then remain turned on while the OFD is turned on and off three consecutive times at intervals of 5 seconds on, 5 seconds off.

Step 3. At a distance of 10 cm from the OFD, the light shall be moved rapidly (0.1 second to either side) side-to-side, across the OFD's face.

Step 4. Steps 1 - 4 shall be repeated with the glass lens cover plate removed from the fixture.

Step 5. These tests shall be repeated twice.

The OFD shall not respond with a fire signal during any of these tests, but shall detect the specified fire during and immediately after these tests.

8.1.1.1.2.7 Special use lights.

Step 1. A black lamp, typically used as an insect-repelling light in commercially available "Bug Wackers", tube No. Ful. 15T8B1, or equivalent, shall be placed a distance of 1 meter (3.3 feet) directly in front of the OFD.

Step 2. The lamp shall be turned on for 30 seconds, and moved rapidly (1 second) through 45 degrees side-to-side from the lamp's center line axis. The light, in a stationary position 1 meter in front of the OFD, shall then be switched on and off 5 consecutive times at 5 seconds intervals between switching.

Step 3. With the light on, and located in front of the OFD at a distance of 1 meter (3.3 feet), the OFD shall be turned on and off three consecutive times at intervals of 5 seconds on, 5 seconds off.

Step 4. The light shall then be moved to a distance of 3 meters (10 feet) and the chopper apparatus operated at the frequencies and times stated in paragraph 8.1.1.1.1.

These tests shall be repeated twice. The OFD shall not respond with a fire signal during any of these tests.

8.1.1.1.3 Test procedures for Category 2 sources-reflected radiation/light.

8.1.1.1.3.1 Colored objects/surfaces/materials.

8.1.1.1.3.1.1 Colored cloth/clothing. The following colored materials (nylon cloth) shall be placed, at different times, directly in front of the OFD: (1) fluorescent orange, MIL-P-40061, US Army shade 230; (2) fluorescent red, MIL-P-40061, US Army shade 229; (3) bright yellow, commercial grade, and (4) bright white.

Step 1. A dual (2) 40 W, 48" length, "cool white" (or workbench) fluorescent light fixture with a white enamel reflector shall be placed 30 cm to the side of the OFD with its center line axis parallel to the OFD's center line axis (see figure 8).

Step 2. The cloth materials shall be located, one at a time, on the flat surface shown in figure 8, at a distance of 2 meters from the OFD. The light shall be switched on and off consecutively 5 times at intervals of 30 seconds on, 30 seconds off. The light shall then be left on while the OFD is switched on and off 5 times at intervals of 30 seconds on, 30 seconds off.

Step 3. The material shall then be moved to a distance of 1 meter from the OFD and the previous test procedures repeated.

Step 4. The material holding fixture shall then be moved to a distance of 3 meters from the OFD. The chopped light apparatus shall be placed 10 cm in front of the OFD (not affecting the light source) and operated at the frequencies and time stated in paragraph 8.1.1.1.1.

Step 5. The above test procedures shall be repeated with the following light sources, or their equivalents, replacing the fluorescent bulb.

A. 150 W incandescent frosted light

B. 300 W QTH lamp without glass cover plate

C. 400 high pressure sodium, quick start, vapor lamp without glass cover plate on fixture

D. 1000 W metal halide vapor without glass cover plate on fixture

E. 1000 W mercury vapor lamp without glass cover plate on fixture

F. 1000 W Xenon lamp without glass cover plate on fixture

G. red flashing lamp

H. 1000 W photo-flood

I. photographic flashtube at 2000 W-sec (Norman 2000B Strobe- LH2000 or equivalent).

<u>Step 6.</u> Each of the colored materials stated above shall be cut in strips of size 10 cm width x 60 cm length. The strips shall be hung side-to-side on a string such that no two same colors are adjoining. The string with colored strips shall be hung 1 meter in front of the OFD such that the center of the strips is on-line with the center axis of the OFD. A fan or blower device shall then be used to cause irregular "flapping" of the cloth strips "in the wind". While this flapping is in progress, the light sources listed in steps 1 through 5 above shall be used to illuminate the flapping materials. Each light source or equivalent shall remain on for 30 seconds during the test. This test simulates the various colored cloth strips used on aircraft to denote weapons, and on other vehicles and AGE items for other purposes.

This tests shall be repeated twice.

8.1.1.1.3.1.2 <u>Colored surfaces</u>. Separate colored panels, approximately 1 meter x 1 meter in size, painted very high gloss bright white, bright red, bright yellow, and bright orange, will be required for this test. A fifth panel shall be painted in stripes of alternating colors such that the following pattern is made: white, orange, red, yellow, white, orange, red, yellow. The test procedure is basically the same as that in paragraph 8.1.1.1.3.1.1 above, except for a few deviations. The same light sources shall be used.

<u>Step 1.</u> A dual (2) 40 W, 48" length, "cool white" (or workbench) fluorescent light fixture with a white enamel reflector shall be placed 30 cm to the side of the OFD with its center line axis parallel to the OFD's center line axis (see figure 9).

<u>Step 2.</u> The painted panels shall be located, one at a time, 2 meters directly in front of the OFD as shown in figure 9. An easel can be used or some method of maintaining the panel's face normal to the line-of-sight of the OFD. The light shall be switched on and off consecutively 5 times at intervals of 30 seconds on, 30 seconds off. The light shall then be left on while the OFD is switched on and off 5 times at intervals of 30 seconds on, 30 seconds off. With the light on, the striped panel shall be moved back and forth in rapid motion for 30 seconds.

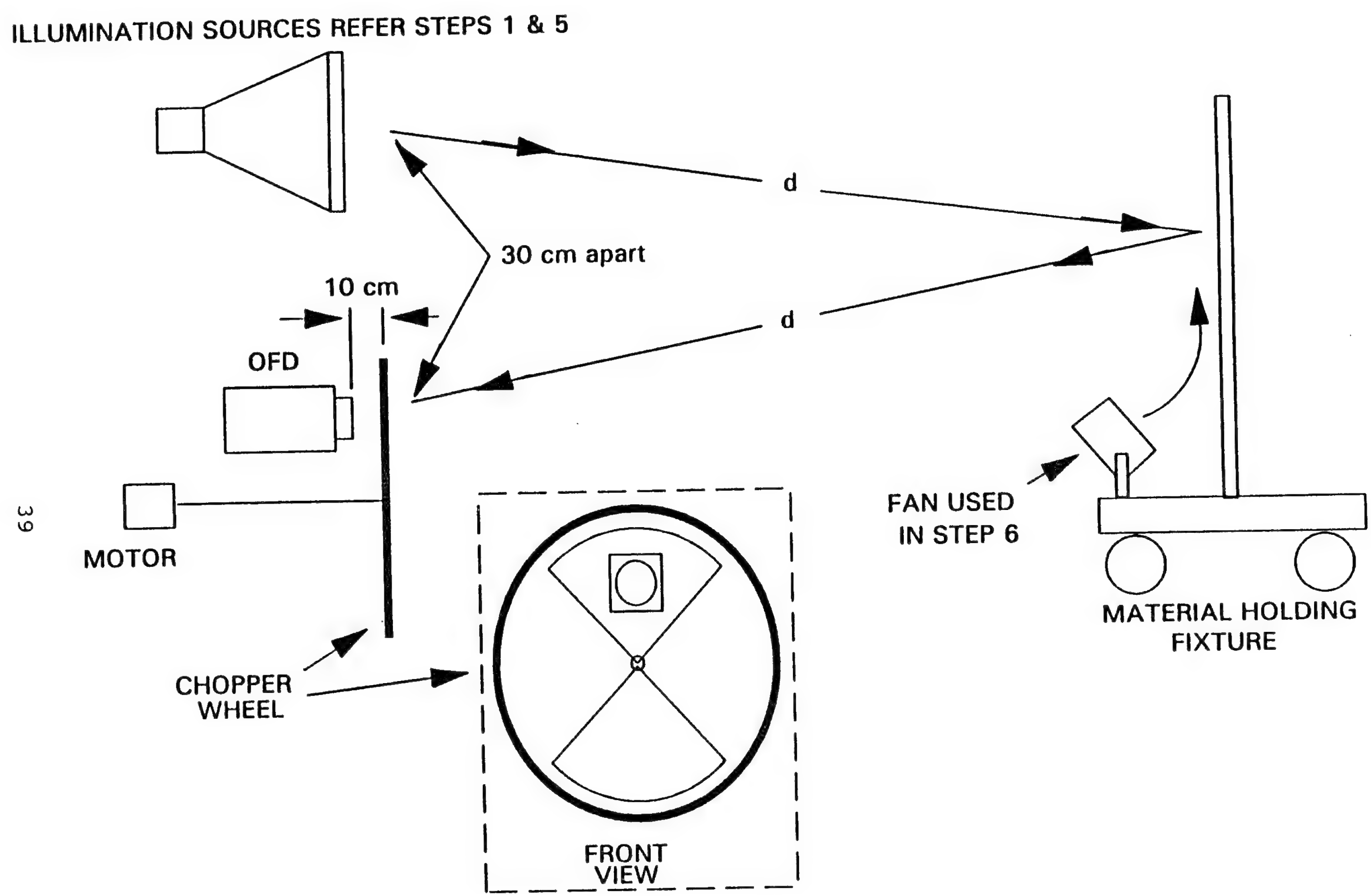


Figure 8, Refer 8.1.1.1.3.1
COLORED OBJECTS/SURFACES/MATERIALS TEST CONFIGURATION

Step 3. The panels shall then be moved to a distance of 1 meter from the OFD and the previous test procedures repeated.

Step 4. The panel material holding fixture (easel) shall then be moved to a distance of 3 meters from the OFD. The chopped light apparatus shall be placed 10 cm in front of the OFD (but not in front of the light source) and operated at the frequencies and times stated in paragraph 8.1.1.1.1.

Step 5. The above test procedures shall be repeated with the following sources, or their equivalents, replacing the fluorescent bulb.

A. 150 W incandescent frosted light

B. 300 W QTH lamp without glass cover plate

C. 400 high pressure sodium, quick start, vapor lamp without glass cover plate on fixture

D. 1000 W metal halide vapor without glass cover plate on fixture

E. 1000 W mercury vapor lamp without glass cover plate on fixture

F. 1000 W Xenon lamp without glass cover plate on fixture

G. red flashing lamp

H. 1000 W photo-flood

I. photographic flashtube at 2000 W-sec (Norman 2000B Strobe-LH2000 or equivalent).

J. 1500 W radiant heater without fan operated at maximum power setting (keep on 10 minutes)

8.1.1.1.3.2 Fluid surfaces. Two fluids, water and oil, will be required for this test. The oil can be common light weight automobile oil, but must be clean.

Step 1. The OFD shall be mounted approximately 150 cm above the floor, with the center line axis of the FOV pointed at an angle of 45 degrees. See figure 10.

Step 2. An oil pan or other type of pan of approximate dimensions 1 meter x 1 meter (or larger), shall be placed on the floor with its center 150 cm directly in front of the OFD (see figure 10). The pan shall then be filled with water to the top.

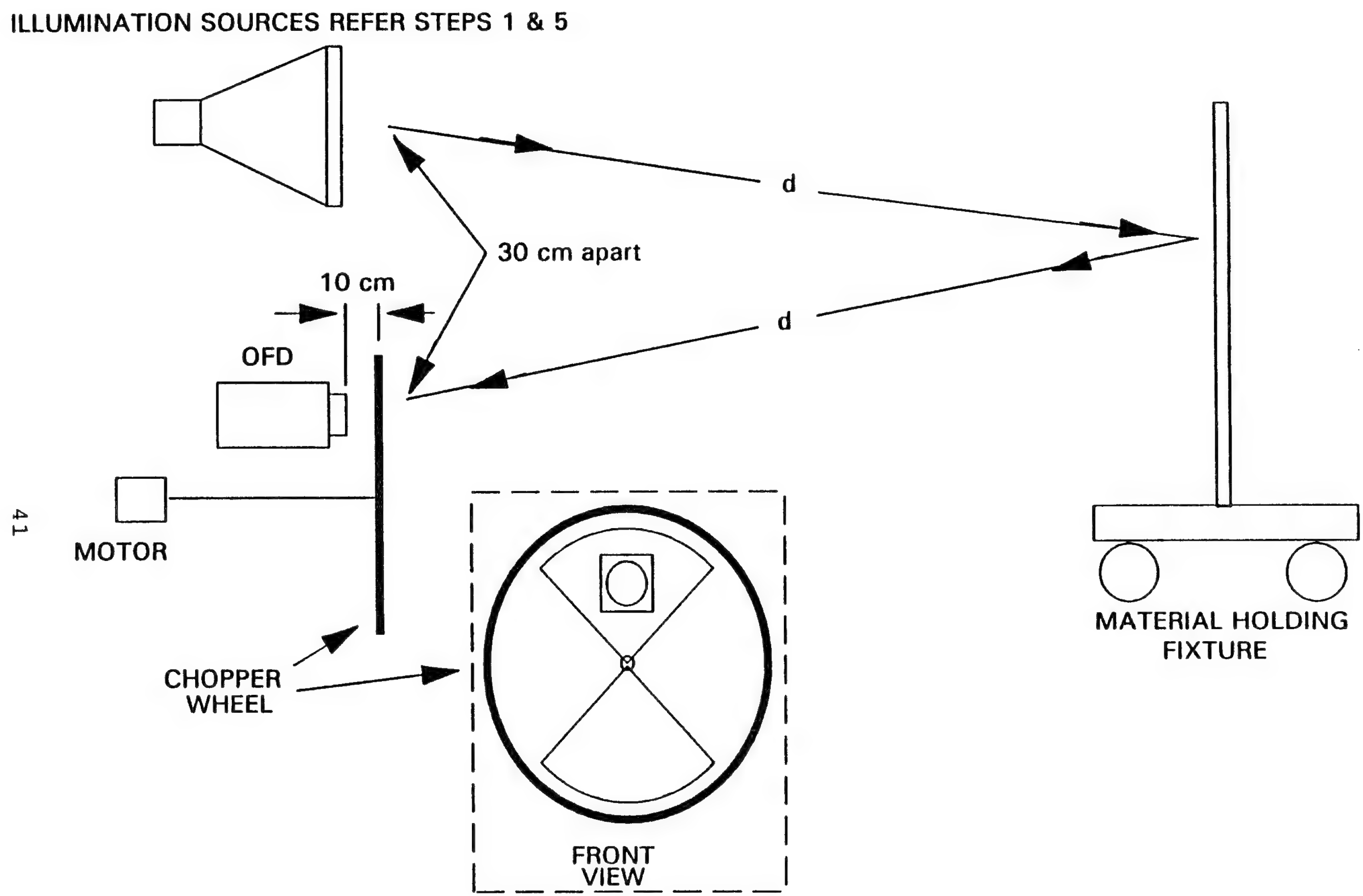


Figure 9, Refer 8.1.1.1.3.1.2
COLORED OBJECTS/SURFACES/MATERIALS TEST CONFIGURATION

Step 3. The light sources listed in paragraph 8.1.1.1.3.1.2 shall be mounted, one at a time, 150 cm above the floor and pointed 45 degrees down and directly in front of the OFD.

The first light, a dual (2) 40 W, 48" length, "cool white" (or workbench) fluorescent light fixture with a white enamel reflector, shall be mounted on the fixture lengthwise and pointed 45 degrees down.

Step 4. The light shall then be turned on for 3 minutes, after which the light shall be switched on and off consecutively 5 times at intervals of 30 seconds on, 30 seconds off. The light shall then be left on while the OFD is switched on and off 5 times at intervals of 30 seconds on, 30 seconds off.

Step 5. The chopped light apparatus shall be placed 10 cm in front of the OFD and operated at the frequencies and times stated in paragraph 8.1.1.1.1.

Step 6. The above test procedures shall be repeated with the following sources, or their equivalents, replacing the fluorescent bulb.

A. 150 W incandescent frosted light

B. 300 W QTH lamp without glass cover plate

C. 400 high pressure sodium, quick start, vapor lamp without glass cover plate on fixture

D. 1000 W metal halide vapor without glass cover plate on fixture

E. 1000 W mercury vapor lamp without glass cover plate on fixture

F. 1000 W Xenon lamp without glass cover plate on fixture

G. red flashing lamp

H. 1000 W photo-flood

I. photographic flashtube at 2000 W-sec (Norman 2000B Strobe- LH2000 or equivalent).

J. 1500 W radiant heater without fan operated at maximum power (keep on 10 minutes)

Step 7. The tests shall be repeated once.

Step 8. 2 quarts of water shall then be removed from the pan and the oil poured over the remaining water up to the top of the pan.

Step 9. The above steps 2 through 7 shall be conducted.

8.1.1.1.3.3 Polished metals, glass, mirrors. In place of the two fluids in test paragraph 8.1.1.1.3.2 above, this test requires a mirror and aluminum foil. The mirror should be approximately 1 meter x 1 meter. A 1 m x 1 m panel of poster material or thin plywood shall be covered with aluminum foil which has been "crinkled" (rough surface). The bright side shall be facing up.

The tests shall be conducted with the sources and procedures specified in paragraph 8.1.1.1.3.2 above.

8.1.1.1.4 Test procedures for Category 3 sources- "natural phenomena".

8.1.1.1.4.1 Sunlight

8.1.1.1.4.1.1 Sunlight-radiation.

Step 1. On a cloudless, clear day, the center line axis of the OFD shall be pointed directly at the sun when the sun is near its maximum elevation above the horizon. A solar simulator such as a Xe lamp with appropriate filters can be substituted.

Step 2. The OFD shall be turned on and off 3 consecutive times with 2 seconds between switching actions. After the third switching action the OFD shall continue to face the sun for 1 minute and then rotated back and forth 45 degrees three consecutive times at a rate of rotation of about 45 degrees/second.

Step 3. With the OFD on and facing directly toward the sun, the sunlight shall be "chopped" at frequencies between 1 cycle per second through 25 cycles per second, per the test instructions given in paragraph 8.1.1.1.1. This will be accomplished by placing the chopper apparatus in front of the OFD.

8.1.1.1.4.1.2 Sunlight-ambient temperature. This test is not required in this specification. However, the procurement agency may elect to impose this test of possible actinic effects on the OFD from prolonged exposure to solar radiation. The recommended test procedure is as follows:

The OFD shall be solar radiation tested in accordance with MIL-STD-810, Method 505.2, Procedure II. The test requires a solar radiation source, as so described in MIL-STD-810, Method 505.2, set

to a radiant energy rate of 120 +/- 47 W/m^2 (355 +/- 14 $BTU/ft^2/h$), and a temperature of 40 degrees C (120 degrees F). It should be positioned 76 cm (30 in) directly in front of the powered-up OFD.

Step 2 of the MIL-standard procedure is to be modified to an exposure time of 8 hours. Step 4 of the procedure shall not be conducted. During the 8 hour exposure, the OFD shall not output a "fire" signal. After 8 hours of exposure, the OFD shall be exposed to the procurement agency's specified threshold size fire at the specified distance. The solar radiation source shall be removed from the FOV of the OFD, and the fire immediately ignited. The OFD shall respond with a fire signal within the time specified by the procurement agency.

8.1.1.1.4.2 Lightning. Lightning generates a sudden variation of electric field, a quickly varying magnetic field, and electromagnetic radiation over a broad spectrum. Lightning can affect an OFD by the EM radiation emitted during a flash, or by the electromagnetic fields resulting from a nearby strike. The latter possible effects are not covered by test procedures included herein. Recommended test procedures, however, are listed in paragraph 6.8 herein and may be employed by the user/purchasing agency.

The UV, visible, and IR radiations emitted during a lightning flash may have an influence on OFDs. The average duration of a lightning flash (discharge) is 0.2 seconds and a maximum recorded time of 2 seconds. The number of strokes in a flash is typically 3-4, the maximum recorded being 26. The time interval between strokes averages 40 ms, and the maximum is 100 ms. The following test should be conducted to verify OFD lightning immunity.

A 4000 V electric arc shall be used to simulate lightning discharges. A high voltage ignition or ballast transformer and a 1.2 cm pointed electrode sparkgap shall be mounted directly in front of the OFD, on the center line-of-sight, 30 cm (12 in) from the OFD. The electric arc shall be activated 10 consecutive times for periods of 2 seconds on, 2 seconds off. The OFD shall not respond with a fire signal during any of the 10 tests.

A test to verify the OFD's ability to detect a fire during the presence of such false alarm sources is the responsibility of the procurement agency and depends upon the performance specification they impose.

8.1.1.1.5 Test procedures for Category 4 sources-"electrical arcing and electrostatic discharge".

8.1.1.1.5.1 Electrical discharge/arcing. Electrical arcing can occur over a large range of distances from the OFD, either in the direct line-of-sight or via reflection from highly reflecting

surfaces. Typical types of electrical discharges include transformer arcing, short circuits in electrical devices, electronic device failure modes, and other electrical-associated events. These discharge events are typically of short duration and physical extent, and appear as bright (lightning-like) arcs. The spectral content is similar to lightning and extends into the far UV. The closest distance of a source from the OFD would be about 60 cm (2 ft), assuming the source was mounted on the wall near the OFD. If the OFD application is such that no sources of arcing exist any closer than 30 cm from the OFD, then, if the OFD passed the tests required in 8.1.1.1.4.2, no additional tests are required.

8.1.1.1.5.2 Electrostatic discharge. Electrostatic discharge may also cause false alarms by affecting electronic parts and circuits. Electrostatic discharge is generated by the relative motion or separation of materials or flow of liquids, vapors or gases. Common sources include personnel, items made of plain plastics, tools, test equipment. Electrostatic discharge sensitive parts include microcircuits, discrete semiconductors, thick and thin film resistors, chips, hybrid devices and piezoelectric crystals. Although not required herein, the procurement agency may stipulate a test to verify that under conditions of electrostatic discharge of 1000 to 4000 volts that the OFD does not fail or falsely alarm the presence of fire. MIL-STD-1686 references electrostatic discharge control programs for protection of electrical and electronic parts, assemblies and equipment.

8.1.1.1.6 Test procedures for Category 5 sources-"non-destructive investigative devices (X-rays)". Should x-ray operations be permitted within or near to the facility or location where the OFD (or system) is located, the following test procedure may be imposed by the procurement agency.

A 300 KV industrial x-ray apparatus, such as a Sperry Model 300C (NSN 6635-01-064-7018; Part No. 65D300) shall be employed. A 35-40 degree cone of emission directional tube shall be used. The tube shall have a tungsten target and a beryllium window. The center of the output beam shall be directed at the center of the OFD, located at a distance of 10 meters (33 ft). After the OFD has been operating for 30 minutes, the x-ray machine shall be operated in steps of 50 KV up to 300 KV and operated at currents of 5 and 10 milliamperes at each 50 KV step. The OFD shall then be rotated 90 degrees to its side and the test repeated. The OFD shall then be rotated another 90 degrees so that the back of the OFD is facing the x-ray emitter, and the tests repeated. Maintaining this latter configuration, about a 30 cm x 30 cm piece of corrugated steel (type normally used in hangar/shelter construction), 0.16 cm thick, shall be placed against the back of the OFD, facing in the direction of the x-ray emitter. The tests shall then be repeated at the same settings as before.

The OFD shall not respond with a fire alarm during these tests and shall continue to meet its fire detection threshold requirements after the tests are conducted.

8.1.1.1.7 Test procedures for Category 6 sources-"electromagnetic radiation". OFD sensors and electronics exposed to electromagnetic (EM) radiation of certain frequencies and EM field power densities may false alarm or malfunction. Such EM sources may differ in their nature and properties from one Air Force base location to another. The specific EM environment, and associated qualification test requirements, will therefore be defined by the procurement agency for the specific application.

The tests recommended herein however, to verify false alarm immunity to EM radiation, follows MIL-STD-461 (Category A1c of Class A1 equipment for Air Force) and MIL-STD-462 test procedure requirements. Only the susceptibility tests in these standards relate to OFD false alarm immunity. The recommended tests are paragraphs CS01, CS02, RS02, RS03, in Part 2 of document MIL-STD-461. Other recommended tests, which have limited applicability, include: include CS03, CS04, CS07, CS11, and RS05.

8.1.1.1.7.1 Portable handheld radio communications. Either a military or similar commercial 5 W handheld "Walkie-Talkie"-type of radio, shall be employed for this test. One military version is the Motorola Saber unit, NS# 5820PH99QX/052H. The radio handset shall contain fresh batteries. Should the radio contain more than one frequency band, the highest frequency band shall be used.

Step 1. The handheld radio shall be set at maximum transmission power. The radio's antenna shall be placed 10 cm directly in front of the OFD face lens. Transmission should occur in short "bursts" of 5 seconds on, 5 seconds off.

Step 2. Maintaining the antenna distance of approximately 10 cm, the radio shall be operated at maximum transmission power level for 2 minutes. During this period the radio shall be moved around the OFD from side-to-side.

Step 3. The radio's antenna shall then be held in contact against the OFD's metal surface and operated for 2 minutes at maximum transmission power.

8.1.1.1.7.2 Aircraft radar. The requirement pertaining to radar will, in general, be satisfied by the MIL-STD-461 tests recommended in 8.1.1.1.7. The procurement agency will specify any other requirements.

8.1.1.1.7.3 Electronic switching devices. Electrical generators, relays, switching power supplies, and other electronic devices emit EM radiation that may affect other electronic devices, such as an OFD, either in the immediate vicinity or as part of the

same electrical circuitry. The recommended tests in paragraph 8.1.1.1.7 above cover the induced environmental effects, except transient effects that may be associated with power surges and/or pulses from power supply disruptions. Other possible effects are related to the OFD design itself. OFD design specifications may be imposed by the procurement agency. They are not part of this specification.

8.1.1.1.7.4 Aircraft subsystem emissions. Aircraft communication jammers, radar detection jammers, and "heat seeker" IR jammers emit both IR radiation as well as electromagnetic radiation. Under special conditions these subsystems may be operated in the immediate vicinity of an OFD, either in a test or during repair and maintenance. Specification of tests pertaining to these subsystems are the responsibility of the procurement agency and depend upon the specific environment to which the OFD would be exposed.

8.1.1.1.7.5 EMP (Electromagnetic Pulses). EMP is not a requirement herein, but may be a requirement depending upon the specific application of the procurement agency.

8.1.1.1.8 Test procedures for Category 7 sources-"aircraft engine emissions". Aircraft engine exhausts can affect various types of OFDs. In shelters which have exit exhaust ports, engines may be operated at 80-90% power levels. In other hangars engines are operated at sufficient power levels to taxi in or out. At the higher power levels, without afterburners on, the exhaust effluent spectral emissions are mostly in the IR with some UV being present. These engine exhaust emissions have been attributed to several fire detector false alarms, including IR, UV, UV/IR detector types, as well as temperature rate-of-rise detectors. In some instances false alarms were associated with engine start-ups when the exhaust effluent impacted directly upon the OFD.

The nozzle exhaust temperature at military power is, on the average, about 650 degrees C (typical T-38 engine). Depending upon the FOV of the OFD and the angle of view with respect to the exhaust effluent stream, a hot blackbody source of IR radiation may be presented to the OFD. UV emission in the 220 nm to 250 nm region without an afterburner on would be in the range of about 1×10^{-9} to 1×10^{-11} W/sr-nm. If the detector's FOV included "looking down the throat of the engine), it would see a flame source much with higher irradiances in the UV and IR.

In the afterburner mode, the size and characteristics of the flame ranges from a very small protruding flame, such as from the Tornado, to a very long flame, such as from the F-15, F-111, or F-16 engines. Although not an approved operating procedure, other than in "hush houses" or mounted on outside engine test stands, it must be assumed that an afterburner can be operated for 1-2 seconds

inside a shelter with an exhaust deflection/exit port, for whatever reason.

Also, because of the distribution and layout of shelters/hangars with respect to active taxiways and runways, afterburners may be visible to an OFD (either installed in a facility or mounted on a mobile platform) during aircraft takeoffs and/or trim pad runups. The afterburner-emitted radiation could be directly in the OFD's FOV or reflected into the OFD's FOV. The distance between an aircraft taking off with afterburners on and an OFD may be as close as 0.5 km (1,640 ft) at some AF and/or NATO bases. There are also situations at some flow-through shelters where an aircraft engine could be put into "AB" mode almost immediately after the aircraft has left the shelter (such facilities may not presently have fire detectors). There is a distinct probability, therefore, that afterburner spectral emissions may be present within the FOV of an OFD.

The spectral emissions in the AB mode are about two orders of magnitude greater when looking from the end to nose compared to a side view.

8.1.1.1.8.1 UV emissions. The UV spectral radiant flux from an aircraft engine depends on the engine type, its power setting, and whether the AB is in operation. The intensity levels are also a function of look angle, end-to-nose being the most intense. However, for purposes here, the afterburner spectral radiant flux emission curve in the mid-UV can be assumed to follow a "representative" blackbody temperature of about 2500 - 2800 degrees K. In the band from about 190 - 260 nm, where most OFD's operate, the radiant flux at 10 meters from an F-15 in AB was measured to be about 5.5×10^{-3} W/cm^2 looking side-on. Looking end-on toward aircraft nose, this irradiance number at 10 meters could be as high as 5.5×10^{-1}. Looking side-on, the irradiance then at 100 feet distance (30.3 meter) is about 4×10^{-3} W/cm^2 in the band 190 nm - 260 nm, with atmospheric correction (see below). This means that looking side-on to an AB flame as the aircraft is either taxiing or airborne, assuming a detector's irradiance threshold in this band was set to the equivalence of a 2' x 2' JP-4 pan fire at 100', the detector's irradiance would be satisfied to a distance of about 450 feet to as much 900 feet depending upon what JP-4 fire irradiance number is used.

In calculating the expected irradiance at the OFD as a function of distance, the transmittance in the atmosphere must be taken into account, especially in the far UV. Using the Ontar LOTRAN model for a desert climate such as at Edwards AFB, the transmittance at 15 meters (50 ft) distance drops off almost vertically from 90% at 205 nm to almost zero at 200 nm. Above 205 nm the transmittance continues to rise and reaches 98% at 260 nm. The average transmittance therefore, at the center (220 nm) of the UV band of

interest, at a distance of 15 meters, is about 93%. Therefore, only ten percent of the afterburner-emitted UV of interest is absorbed in the first 50 feet distance. At 100 feet distance the transmittance is 0.86 at the 220 nm wavelength and increases to 0.99 at 280 nm. There is, therefore, only slight atmospheric absorption at wavelengths above 205 nm.

8.1.1.1.8.2 IR emissions. IR emissions from the engine exhaust occur at all engine power settings and reach a maximum level at full afterburner setting. OFDs are exposed routinely to aircraft engine exhaust emissions in hangars, shelters, hush houses, and open areas. In operational shelters such as hardened aircraft shelters, aircraft engines may be operated at up to 80% maximum power setting for some period of time. At these power settings the IR emissions may satisfy the IR spectral irradiance requirements of an OFD.

The predominant IR emissions follow a blackbody curve. Superimposed on the this background curve are spectral emissions in certain distinct bands. In the afterburner mode, three spectral regions are predominant, namely, about 2.0 - 2.5 μm, with a peak near 2.3 μm; about 2.8 - 4.3 μm, with a broad peak between 3.5 and 4.2 μm; and about 4.3 - 5.2 μm, with a peak at about 4.6 μm.

The region of most interest here is 4.2 - 4.7 μm, the band in which most infrared fire detectors operate (the CO_2 absorption band). The region near 2.3 μm may also be used in some detector approaches. In the afterburner mode the irradiance at 4.38 μm (with a band width of 0.7 μm) at 10 meters (33 feet) distance is about 500 microwatts/ cm^2, or about 50 $\mu W/cm^2$ at 100 feet distance. For comparison purposes, a 2' X 2' JP-4 pan fire at 100 ft (30 meters) distance has an irradiance in the same spectral wavelength band of about 15 - 26 microwatts/cm^2. This irradiance is about the same as the afterburner irradiance at 50 meters (165 feet) with atmospheric absorption considered.

8.1.1.1.8.3 Aircraft engine exhaust test procedures.

It is apparent from the very large irradiance values in both the UV and IR throughout the UV, visible, and IR regions, that an aircraft engine in afterburner mode will satisfy the irradiance requirements wherever the bands are set, for distances out to as about 500 - 900 feet in the UV and out to about 150 - 250 feet in the IR. This statement, of course, is based upon the assumption that the irradiance threshold requirements have been specified for a 2 foot x 2 foot JP-4 pan fire at 100 feet distance, or a 1 foot x 1 foot JP-4 pan fire at 50 feet distance. Any other specified fire type, size, and distance would of course directly impact the test procedure requirements.

It is not practical to require an actual false alarm immunity test for an aircraft engine in AB. Instead, a simulation should be used if required by the user/procurement agency.

The approach recommended is to use a propane flame as the spectral emission source. Its UV spectrum in the middle UV closely matches that of an afterburner effluent flame as seen "side-on" (the most probable look angle for a detector). The propane burner should be wide enough to provide a 3" - 6" diameter base flame. A standard "camping propane cooking burner" can be used for this purpose. The intensity/size of the flame can be varied as well as the unit's distance from the detector to satisfy the irradiance requirements in the 190 nm - 260 nm band.

The infrared irradiance in the 4.4 μm band can be simulated using a standard Calrod-type of heating plate. The temperature of the plate can be adjusted to meet the temperature requirement for a black body that has sufficient irradiance in the 4.4 μm band (and 2.3 μm band) to meet the distance requirements specified by the user/procurement agency. The appropriate settings, temperatures, and distances are left to the testing organization to determine depending upon the specification provided by the user/procurement agency.

Tests should be conducted however for engine exhaust effluent exposure to and/or impingement on a OFD. For this test a standard heat gun, with or without a fan, and hot plates can be used.

<u>Step 1.</u> After the OFD has been on for 30 minutes, a handheld heat gun (electric paint remover) should be activated and allowed to heat up to maximum temperature (about 2 minutes). The heat gun shall then be held 30 cm from the OFD, pointing 90° across the OFD's FOV. The heat gun shall be held in this position for 2 minutes.

<u>Step 2.</u> The heat gun shall then be held a distance of 60 cm from the OFD, and pointed directly at the face of the OFD. Hold this position for two minutes.

<u>Step 3.</u> The gun shall then be moved slowly back and forth through the entire 90° FOV of the OFD.

<u>Step 4.</u> Repeat these tests twice.

The OFD shall not respond with a fire signal during any of these tests.

8.1.1.1.9 <u>Test procedures for Category 8 sources-"personnel items-smoking materials"</u>.

8.1.1.1.9.1 <u>Lit cigarette/cigar</u>. A lit cigarette shall be placed directly in front of the OFD at a distance of 2.54 cm (1

inch) and moved from side-to-side in approximately a 15 cm (6 in) arc as rapidly as possible for ten (10) seconds. The OFD shall then be turned on and off twice with 5 seconds between each switching action while the OFD continues to be moved in the same manner. After these procedures are completed, a lit cigarette shall be held directly in front of the OFD at a distance of 1 meter and moved rapidly in a straight line toward the center of the OFD's lens surface. The OFD shall then be turned on and off twice in rapid succession while the lit cigarette is again moved from 1 meter to the lens surface of the OFD. These procedures shall be repeated with a lit cigar.

8.1.1.1.9.2 Lit matches. A paperbook match shall be lit at a distance of 2 meters (6.6 feet) directly in front of the powered OFD, exposing the match flare-up to the OFD. The lit match shall then be rapidly moved 45 degrees side-to-side (45 degrees/second), while maintaining a distance of 2 meters. The OFD shall be turned on and off two consecutive times with 2 seconds (regardless of the time necessary to reach operational status) between each switching action while a match continues to be moved in the same manner. Immediately after the third switching action a lit match should be held steadily at 2 meters distance directly in front of the OFD for a time at least equal to the time required for the OFD to reach its operational status. This procedure shall be repeated with a wooden match.

A full book of matches shall then be ignited at a distance of 3 meters (10 feet) directly on the center line axis of the OFD's FOV. The lit match book shall continually be moved side-to-side (one arm's length per second) until the OFD has been turned on and off two consecutive times with 2 seconds between each witching.

8.1.1.1.9.3 Butane cigarette lighter. A pocket-size butane cigarette lighter shall be lit at a distance of 1.5 meters (5 feet) directly in front of the OFD. As in the above tests, it shall then be moved rapidly (about one arm's length per second) 45 degrees side-to-side of the center line axis of the OFD's FOV. The OFD shall be turned on and off three consecutive times with 5 seconds between each switching action while the lighter continues to be moved in the same manner.

The lighter shall then be turned on and off three consecutive times, with 5 seconds between each lighting, while being held 1.5 meters directly in front of the OFD.

8.1.1.1.10 Test procedures for Category 9-"tools/operations".

8.1.1.1.10.1 Welding/cutting operations. Welding/cutting operations are common on most AF bases. However, most operations on aircraft are conducted in one facility, although on some occasions the mobile welding apparatus may be required to be located in other hangar, shelter, or outside locations.

The UV/IR radiations emitted from such operations, may be within the FOV of an OFD, and possibly cause false alarms. The tests required herein take into account the possibility of such welding operations.

After welding operations are concluded on an aircraft, the welded area is "heat soaked" for some time to provide slow cooling to avoid cracking/buckling. Temperatures of about 525 degrees C (1000 degrees F) are maintained with one or more of the following: thermal blankets; quartz IR lamps; propane flame heaters; and induction heaters. These heaters/devices are potential false alarm sources in themselves and are discussed in other sections of this specification.

Immunity to welding shall be verified by test using both the arc and acetylene methods in a vertical or horizontal lap-weld forming a 1.2 cm (15/32 inch) bead, 30 cm (12 inches) long. The following types of materials and welding/cutting processes are used on AF bases. For purposes herein, tests shall be conducted with process #4 and either #1 or #2. Process #2 has been selected herein for example.

1. TIG Welds (Tungsten inert gas) :
   - (A) Aluminum 6061, with 4043 rod
   - (B) Magnesium, with AZ 318 rod
   - (C) Titanium, with Titanium filler rod
   - (D) Carbon steel, with 410 rod

2. ARC Welds :
   - (A) Steel plate, with 6013 rod
   - (B) Carbon steel, with 6013 rod
   - (C) Stainless steel, with 312-16 rod
   - (D) Nickel, with Nickel 141 rod
   - (E) Aluminum, with eutectic super 2109 rod

3. MIG Welds :
   - (A) Aluminum 4043, with ER 70-6 wire
   - (B) Mild steel, with ER 70s-6 wire

4. Oxyacetylene Cutting and Weld
   - (A) Mild steel, cut
   - (B) Mild steel weld, with mild steel rod

<u>Step 1.</u> The materials to be welded/cut are stated above. Each material should be between .3 and .6 cm (1/8" and 1/4") thick, and about 30 cm x 10 cm (12" x 4"). The rod should be 0.4 cm (5/32") diameter. The current should be set at 300 Amps. The welding/cutting equipment and fixture shall be located 5 meters from the OFD. The OFD shall be mounted approximately 1 meter above the floor. The welding fixture/platform should also be about 1 meter above the floor.

<u>Step 2.</u> The OFD shall be turned on. After 30 minutes two steel plates, of the dimensions stated above, shall be welded together directly in front of the OFD, at the distance stated above. A 6013

steel 0.4 cm (5/32") rod shall be used. The welding operation should be continued for 2 minutes.

Step 3. Step 2 shall be repeated, during which the OFD shall be turned on and off 3 consecutive times at 5 second switching intervals.

Step 4. Steps 1, 2, and 3 shall be repeated with carbon steel plate using the same size and type of rod.

Step 5. Steps 1, 2, and 3 shall be repeated with stainless steel plate using 312-16 rod.

Step 6. Steps 1, 2, and 3 shall be repeated with Nickel plate using Nickel 141 rod.

Step 7. Steps 1, 2, and 3 shall be repeated with Aluminum, using eutectic super 2109 rod.

Step 8. With the OFD turned on, an acetylene torch, with flame size 1.6 cm x 15 cm (5/8" x 6"), and 00 tip, shall be used to cut a plate of mild steel a distance of about 5 cm, or long enough to maintain cutting operations for 2 minutes.

Step 9. Step 8 shall be repeated, during which time the OFD shall be turned on and off as so stated in step 3.

During these welding/cutting operations, the OFD shall not respond with a fire signal. Any required test to proved the OFD's ability to detect a fire of some threshold size and distance shall be stipulated by the procurement agency.

8.1.1.1.11 Test procedures for Category 10-"hot bodies, blackbody radiators". This category includes all items that may have temperatures high enough to emit sufficient energy in the 3-5 micrometer band to be detected by an IR OFD.

8.1.1.1.11.1 Vehicle and AGE manifolds, engines, exhausts. There are many types of aircraft ground equipments (AGE). They include power generators, compressors, heaters, air conditioners, floodlights, hydraulic test systems, front-end loaders, ammunition loaders, bomb loaders, pressurized cabin leak testers, LH_2 carts, LOX carts, hydrazine exchangers, and other support equipment. These AGE types are operated by either gasoline-, diesel-, or JP-4-fueled engines, which have exposed hot exhaust pipes and manifolds.

These hot surfaces have temperatures between 300 degrees C (572 degrees F) and 650 degrees C (about 1200 degrees F). In this temperature range, assuming an ideal blackbody, the maximum wavelength of the radiated radiation ranges between 3.3 micrometers and about 5 micrometers. The areal dimensions of these hot

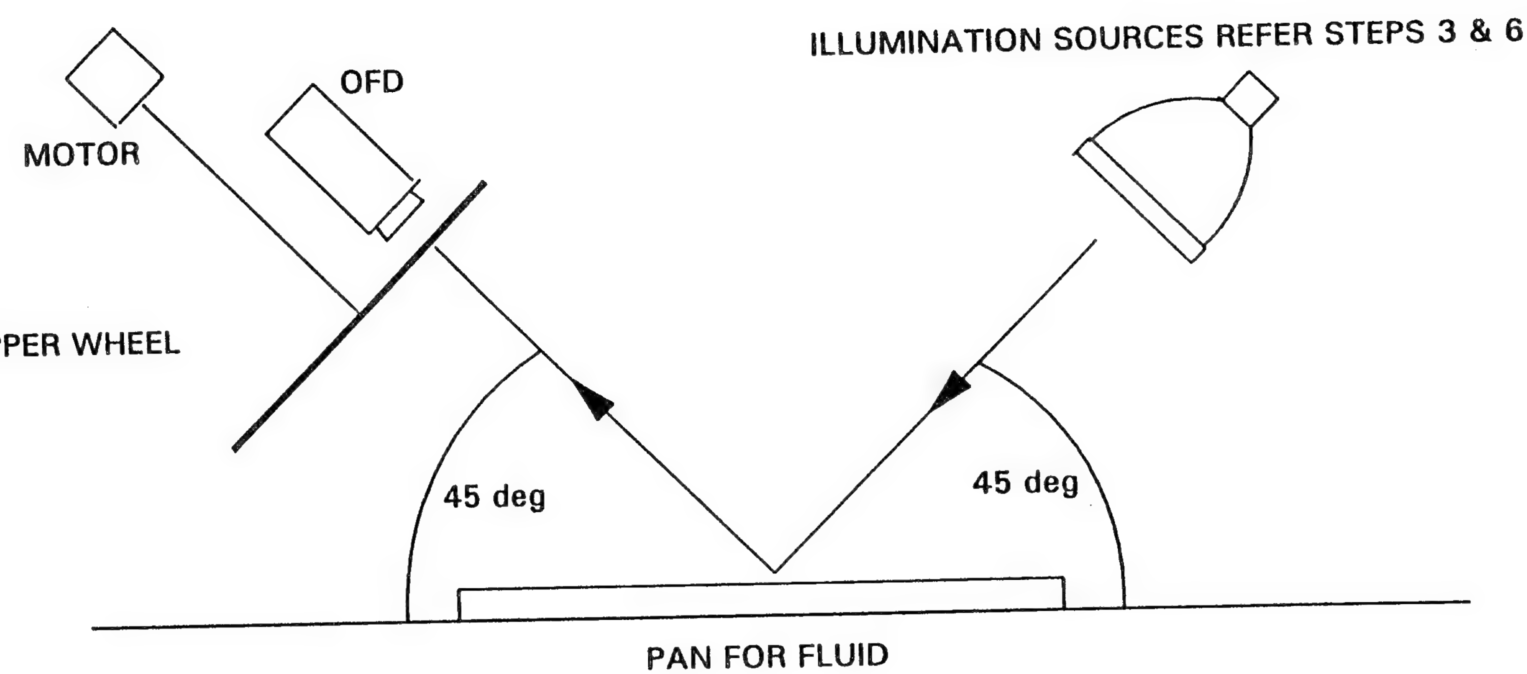


Figure 10, Refer 8.1.1.1.3.2

FLUID SURFACE TEST CONFIGURATION

surfaces vary between 500 cm^2 to about 4000 cm^2. Figures 11 and 12 show several AGE types and their respective hot exhausts/engines.

Depending upon the specific AF base regulations and/or conditions, certain AGE types may or may not be permitted inside hangars, shelters, or support facilities. In terms of the tests described herein, it is assumed that a large range of sizes of hot bodies with temperatures up to 650 degrees C can be located inside any facility at any time, and be located/exposed in the FOV of a OFD.

The following hot body tests shall utilize a two element electrical calrod cooking plate. It should be possible to regulate the temperatures of both elements to the same value.

<u>Step 1.</u> The dual element hot plate shall be mounted on a movable fixture in the vertical position facing the OFD as shown in Figure xx. The hot plates shall be mounted 1 meter above the floor. The OFD shall be mounted at the same height on a separate fixture. The hot plate fixture shall be located a distance of 2.5 meters from the OFD.

<u>Step 2.</u> The OFD shall be turned on. After the OFD has operated for 10 minutes, the dual hot plate shall be turned on and allowed to gradually heat to a temperature of 100 degrees C (which equates to an ideal blackbody radiative wavelength of 7.7 micrometers and a radiated power of 0.11 W/cm2). During the heating stage the OFD shall be turned on and off 5 times at intervals of 30 seconds.

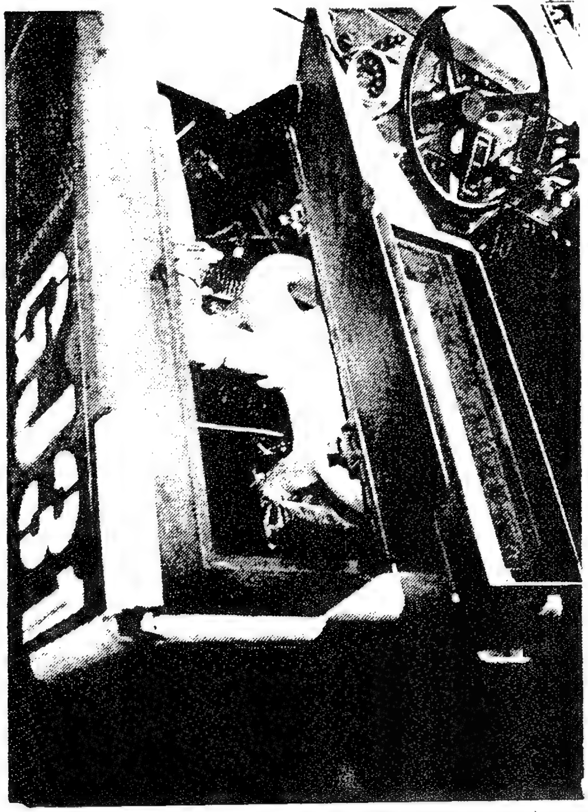
<u>Step 3.</u> After the temperature reaches 100 degrees C, it shall be maintained at this level for 10 minutes.

<u>Step 4.</u> After the 10 minute exposure period in step 3, the chopper apparatus shall be placed immediately in front of the OFD and operated at the frequency settings and times described in paragraph 8.1.1.1.1.

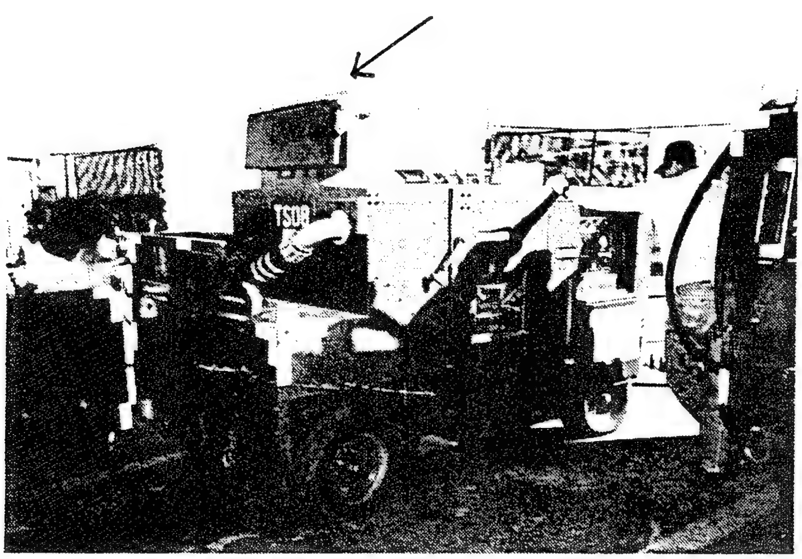
<u>Step 5.</u> These tests shall be conducted twice.

<u>Step 6.</u> Steps 1-5 shall be repeated for the following temperature settings: 200 degrees C (corresponding to 6.0 micrometers maximum wavelength and a radiated power of 0.3 W/cm^2); 400 degrees C (4.3 micrometers maximum wavelength and a radiated power of 1.2 W/cm^2); and 650 degrees C (3.1 micrometers maximum wavelength and a radiated power of 4 W/cm^2). As in the first test above, the hot plates shall be cold when the test begins and heated gradually to these temperature settings. Each temperature test shall be conducted twice, including the chopper tests.

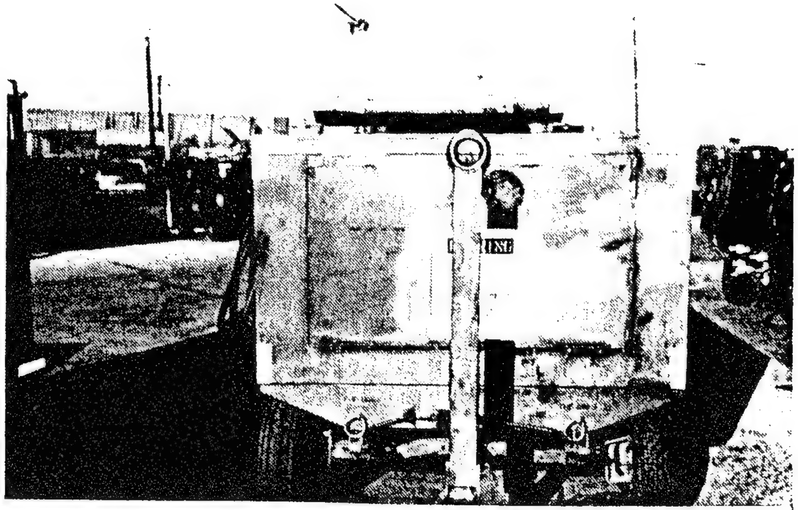
During the entire series of tests, the OFD shall not respond with a fire signal. A test to verify the OFD's ability to detect the procurement agency's prescribed threshold fire during and



MHu 83B-E Bomb Lift Truck (note hot exhaust manifold that is exposed during operations)

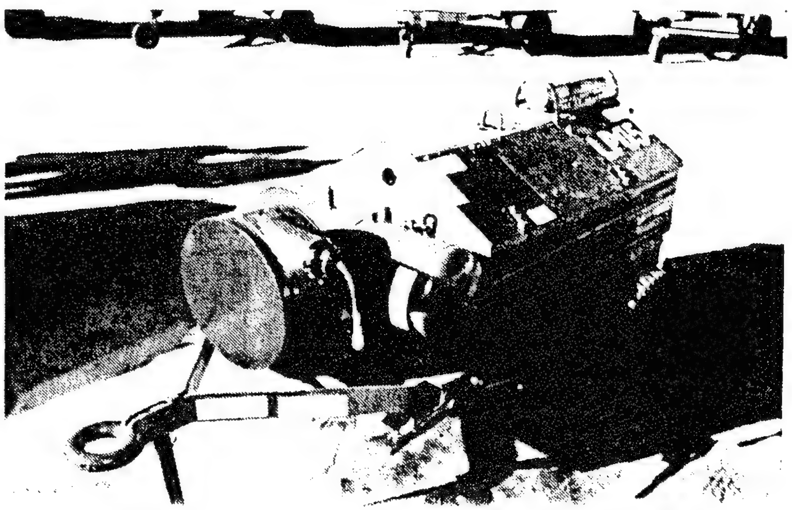


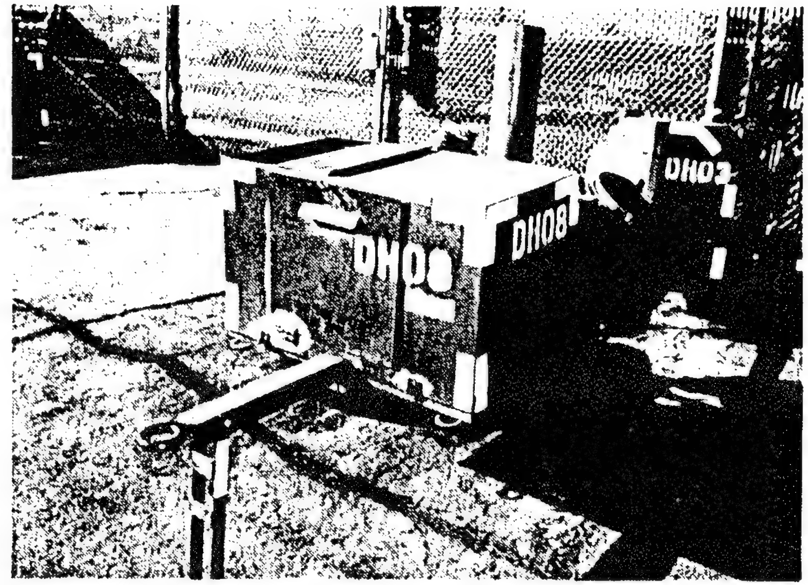
A-M32A-95 Turbine Compressor (note large exhaust area flame/back-fire events occur)



MJ2A Hydraulic Test Stand

MC2A Air Compressor





A-M-32-86 Generator

Figure 12. Examples of AGE "Equipments" and Their Hot Radiator Surfaces

immediately after the above tests is the responsibility of the procurement agency.

8.1.1.1.11.2 Aircraft heaters/blowers.

Step 1. This test shall utilize a 1500 W handheld hair dryer. The unit shall be turned on full fan speed power and full heat power. The unit shall then be held 0.5 meters (1.6 feet) below the OFD, 0.5 meters (1.6 feet) in front of the OFD, pointed upwards (see figure xx). The hair dryer shall remain on for 5 minutes.

Step 2. The hair dryer shall then be held 2 meters directly in front of the OFD and pointed about 30 degrees off the OFD's center line axis of its FOV. This is to assure that the heating element of the dryer, which should be very hot (red), is not seen, but only the hot air.

Step 3. The test shall be repeated twice.

The OFD shall not signal a fire alarm during these tests.

8.1.1.1.11.3 Personnel/facility heaters (described in Category 8a and 8b). A variety of personnel heaters may be found at different base locations. The most common radiant heaters are 1000 W and 1500 W, and are usually located on the floor. These heaters have normal sheath temperatures of about 750 degrees C (1382 degrees F). Heaters with higher wattage have maximum temperatures of about 750 degrees C. Gas or electrical heaters may be mounted on the facility wall or ceiling, from 3 meters to heights as great as 20 or so meters above the floor. Radiant "strip" heaters as long as 10 meters or so, that use gas as a fuel, operate by heating a ceramic rod which reradiates in the infrared. Optical fire detectors may be located "high" inside a facility and be subjected to this IR radiation. However, "puffs" of fire may occur when these and kerosene-type heaters are started (restarted). These "puffs" of fire fall into Category 12 and are covered in paragraph 8.1.1.1.13.

Step 1. A 1500 W radiant heater shall be placed directly in front of the OFD at a distance of 2.5 meters (8 ft). After the OFD has been on for 10 minutes, the heater shall be turned on and allowed to heat to maximum temperature.

Step 2. After 1 hour, the OFD shall be turned on and off 3 consecutive times at a switching interval of 5 seconds on, 5 seconds off.

Step 3. After these switching tests, and with the heater at maximum temperature, the chopper apparatus described in 8.1.1.1.1 shall be placed 10 cm directly in front of the OFD facing the heater so that it occupies all the OFD's FOV. The chopper shall be operated at 0.5, 1-, 3-, 5-, 7-, 10-, 15-, 20-, and 25 Hz for 1

minute at each frequency setting.

Step 4. The heater shall then be allowed to cool to ambient room temperature. The chopper apparatus shall remain in the same position, close to the OFD, and set and maintained at a frequency of 1 Hz. The heater shall then be turned on and allowed to heat up to its maximum temperature.

Step 5. Repeat step 4 at chopper frequency settings of 5-, 10-, and 20 Hz.

Step 6. All the above tests shall be repeated twice.

During these tests, the OFD shall not respond with a fire signal. A test to verify its ability to detect the threshold size fire at the required distance and time will be specified by the procurement agency.

8.1.1.1.11.4 Aircraft brakes, engine nozzles, pods. After a sortie mission, or in certain situations while on the ground, an aircraft's engine nozzles, brakes, and exterior pods may be very hot. To an OFD, these hot bodies appear as IR emission sources. They can be easily simulated as blackbody radiators. Their peak temperatures however, excluding afterburner operation, will not exceed the temperatures of other sources such as personnel heaters, some lights, and some exhaust manifolds. The immunity response tests required for personnel heaters and hot bodies in paragraphs 8.1.1.1.11.1 - 8.1.1.1.11.3 far exceed the requirements covering the sources in this category.

8.1.1.1.11.5 Personnel kerosene heater with fan. Kerosene heaters may be found at some National Guard and other military locations where they are mounted on the shelter/hangar wall about 1.5 - 4 meters above the floor. A 70,000 BTU kerosene heater shall be placed on a level platform 1 - 1.5 meters above the floor. The OFD shall also be mounted the same height above the floor on a separate fixture. The OFD and heater shall be separated a distance of 3 meters. A smaller unit may be used if the distance is reduced to maintain the same effective irradiances.

Step 2. After the OFD has been on for 10 minutes, the heater shall be turned on and allowed to reach its maximum heat output. After the heater has reached this maximum level, the OFD shall be turned on and off 5 consecutive times, 1 second apart.

Step 3. With the OFD operating, the heater shall be turned on and off three times at intervals of 5 minutes between each switching.

Step 4. While the heater is operating at its maximum heat level, the chopper apparatus shall be placed 10 cm directly in front of the OFD so that it occupies all the FOV. The chopper shall then be operated at the frequencies and times specified in 8.1.1.1.1.

8.1.1.1.11.6 <u>Heaters used for curing after welding</u>.

Tests for these thermal blankets would have been satisfied in paragraphs 8.1.1.1.11.2 and 8.1.1.1.11.3.

8.1.1.1.12 <u>Test procedures for Category 11-"weapon discharges"</u>. The procurement agency's application may require OFD immunity to muzzle flashes from small arms/weapons discharges. Certain qualification tests may be required. The most probable weapon discharges in the near vicinity of an OFD include M-16 rifles, M-60 machine guns, M-79 grenade launchers, 38 Caliber pistols, and 12 gauge shotguns. The OFD shall not respond to the following tests. Should these weapons not be available, conventional weapons and blank ammunition may be used, if approved by the procurement agency. A starter's pistol and a 30 Caliber automatic rifle may suffice for this qualification test.

<u>Step 1.</u> An M-16 rifle with 18 round magazine (every third round a tracer), shall be fired semi- and full-automatic at day and night, with barrel end located on, and pointed 90 degrees to, OFD's center line-of-sight, at a distance from the OFD of 1.52 meters (5 feet) distance.

<u>Step 2.</u> An M-60 machine gun positioned 90 degrees to the OFD's center line-of-sight at 3.04 meters (10 feet) distance, fired 5 rounds individually and 30 rounds consecutively.

<u>Step 3.</u> A 38 Caliber pistol positioned 90 degrees to the OFD's center line-of-sight at 1.52 meters (5 feet) distance, fired 3 times separately 10 seconds between firings, and three times in rapid succession (1 second or less between firings).

8.1.1.1.13 <u>Test procedures for Category 12- "aircraft- and AGE-related "fire/explosive events"</u>. As discussed in Section 7.3, certain operations associated with aircraft engine start-ups and AGE item start-ups can result in small explosive fireball events that may be followed by sustained fire. The initial fireball exits out of the exhaust on top of a typical AGE unit such as the M-60 AC Power Cart; out of the undercarriage JFS/fuel vent or nacelle door on fighter aircraft; or out of the engine nozzle. A typical event extending from the gas vent, is about 30 cm in length, lasting for about 1 second or so. The irradiance in the 4.4 μm band, 0.7 μm wide, is about 2.2 milliwatts/cm^2 at a distance of 4 meters.

There are several simulation test procedures that could be followed to test for detector immunity. Two possible procedures are described as follows; Option 2 is recommended because it may be safer.

Test Procedure Option 1

Step 1. To simulate these events, a sturdy metal container, open at the top, of dimensions about 30 cm W x 30 cm L x 60 cm H (1 ft x 1 ft x 2 ft), will be required. The pan should be firmly fastened down so as to prohibit its movement during the explosive tests. A medium size mesh screen (about 5 mm hole size) should be firmly affixed over the top opening to keep liquid from exiting the container at ignition. The mounting configuration should provide sufficient space directly underneath the pan to locate a single element electric hot plate/cooking element with its surface very close to the surface of the bottom of the container.

Step 2. The OFD will be mounted 5 meters (16 ft) from the pan, on the same plane as the container with the center line axis of the OFD's FOV pointed at the center of the container about 30 cm (1 ft) above the bottom of the container.

Step 3. A spark gap ignitor with the gap at the center of the container shall be located approximately 20 cm (8 in) above the bottom of the container.

Step 4. Water should be poured into the pan to a depth of 15 cm (6 in). Sixteen ounces of JP-4 fuel should then be poured on top of the water. Care should be taken to keep the exterior of the container free of fuel and to not spill any fuel around the mounting fixture.

Step 5. The heating unit should then be turned on "high". When the water temperature reaches 212 degrees F (boiling), the heating element should be turned off.

Step 6. After one minute of sitting time the "fuel rich" vapor over the fuel surface is to be ignited with the spark gap ignitor. This will result in an explosive event similar to the backfire events described in Section 7.3. A brief sustained fire will follow.

Step 7. The test shall be conducted twice.

Test Procedure Option 2

Step 1. A 30 cm square pan, 8 - 10 cm deep, shall be placed 5 meters from the OFD so that the center line axis of the OFD's FOV is pointed about 10 cm above the lip of the pan.

Step 2. The pan shall be filled with water to a level of 4 cm from the top of the pan. JP-4 fuel shall then be poured in the pan to a level of 2 cm from the top.

Step 3. The OFD shall be turned on. A black piece of cardboard or other semirigid material about 20 cm x 20 cm, operated as a

"shutter" shall be placed directly over the lens face of the detector such that no light can enter.

Step 4. The JP-4 fire shall be ignited. After the fire has reached it's peak intensity and growth, in about 5-7 seconds, it should be exposed fully to the OFD for a period of 1 second. A "shutter" placed directly against the face of the OFD with the ability to open in 0.1 sec or less and to remain open for 1 second before closing should be provided. This "shutter" effect may be difficult to accomplish by a hand held card. A spring loaded shutter is recommended. The intent is to duplicate the exposure time of an explosive backfire event which typically lasts for 1 second or less.

Step 5. The test shall be conducted twice.

The procurement agency shall specify the detection/suppression performance requirements that are unique to the application. However, for most applications the OFD should not respond with a fire suppressant system activation signal during the early explosive fireball phase of the event, but should alarm to the presence of any resulting fire provided its size meets the minimum size threshold specified by the procurement agency. If the fire event grows to some minimum specified size, within some specified time period, the OFD may also be required to automatically activate the suppressant system.

9. TEST PROCEDURES ASSOCIATED WITH THE PRESENCE OF TWO OR MORE SOURCES OF RADIATION STIMULI

9.1 OFD response. The OFD shall not respond with a signal which represents the presence of "fire" due to the radiation stimuli associated with the combinations of sources indicated in the following paragraphs. Also, the OFD, while in the presence of the multiple sources of radiation stimuli specified herein, shall be able to detect the threshold size fire at the required distance and in the required time as so specified by the procurement agency.

9.1.1 Radiation stimuli. The OFD shall not respond at distances equal to or greater than the specified immunity distance when exposed to the combination of radiation sources indicated in the following paragraphs and tables throughout the FOV of the OFD specified by the procurement agency. This requirement shall be met with the OFD (or system) on; one or more sources turned on and off either individually, in selected combinations, or all at the same time; all sources on, OFD turned on and off; one or more sources on and moved toward and away from the detector; and chopped light (radiation), as specified herein. The combinations of sources represents possible configurations and operations that may occur at any one or more Air Force base locations, including foreign US and NATO bases. Because each application involves different types of possible false alarm stimuli, the user, or purchasing agency, shall

stipulate the combinations that must be used, or simulated, in the false alarm testing. Table 2 contains these source combinations. and their respective distances from the OFD. This table is to be completed by the user agency.

9.1.1.1 Test configuration. The test configuration is dependent upon the most likely positioning of the multiple sources within the FOV of the OFD. Should several possible position configurations exist for a set of multiple sources, the configurations with sources closest to the OFD are specified in the test procedures. Also, some configurations may involve temporal or spatial variations of the radiation stimuli from some of the sources, not all. The following test procedures include potential unique configurations and/or variations of the properties of multiple radiation stimuli. Under certain conditions, the procurement agency may elect to omit a recommended test procedure because the particular source configuration cannot occur within the FOV of the OFD, or the configuration is contrary to Air Force rules and regulations. If, however, there is a real probability that a configuration can occur, then it should be included as a necessary test procedure.

9.1.1.1.1 Chopped light/radiation tests. The method of chopping light (radiations) and the frequencies are described in paragraph 8.1.1.1.1. The radiation stimuli from either one or all the sources present at the same time can be affected by spatial and temporal interruption (chopping) caused by object motions in the line-of-sight between the OFD and the source(s). Such an example may include simultaneous light/sunlight reflections off of standing water being rippled by winds or jet engines, fans operating in front of a radiation heater, and several personnel walking in line between an OFD and a cracked mercury vapor lamp.

This specification requires that each of the listed possible sources of nonfire radiation stimuli undergo chopped light tests. Most sources specified herein as being included in a set of two or more sources, shall also undergo chopped light tests as a group.

A pronounced "chopping" effect on a group of sources would result from several objects moving rapidly, in close succession, across the line-of-sight between OFD and sources, directly in front and close to an OFD, thus possibly chopping all the radiation stimuli in the FOV simultaneously. However, with a FOV of 70-90 degrees and the OFD mounted on the wall 10 or more feet above the floor, it is unlikely that the radiation stimuli from all sources could be

Table 2.

Combination of Sources Required for Tests

[to be completed by user and/or procurement agency]

Grouping	Items Per Group	Distances of Each From Detector
I	lamp a	dist. a
	lamp b	dist. b
	lamp c	dist. c
	lamp d	dist. d
	etc.	etc.

Special instructions:

II	lamp a	dist. a
	lamp b	dist. b
	etc.	etc.

Special instructions:

III	lamp a	dist. a
	lamp b	dist. b
	lamp c	dist. c
	etc.	etc.

Special instructions:

etc.

chopped simultaneously if they were distributed over the full extent of the FOV/footprint. For purposes herein, it is assumed that all false alarm sources assigned to a "multiple sources test" will be located in a narrow region of the field-of-view/footprint unless stated otherwise. In some special cases, the chopper is to be located in front of only one specific source while the other sources in the group/set are not subjected to chopping.

Unless different instructions are provided in the following test procedures, the chopped radiation tests shall consist of the following.

Step 1. Locate the variable speed chopper apparatus at a distance of 10 cm from the OFD.

Step 2. Turn on the OFD and all sources. Operate the rotating chopper wheel/fan blades at frequencies of 0.5-. 1-, 3-, 5-, 7-, 10-, 15-, 20-, and 25 Hz for 30 seconds at each step.

Step 3. Repeat the tests twice.

The OFD shall not respond with a fire signal during the entire chopped radiation test procedure. A test to prove the OFD's ability to detect a specified fire during the above tests is the responsibility of the procurement agency.

9.1.1.1.2 Multiple lights and groupings of lights. There are many possible combinations of different types of light sources, including fixed-in-place (facility and utility), moving sources, aircraft lights, tools, photographic lights, and AGE lights. The tests required herein attempt to cover those possibilities where the most intense lights of different wavelength properties and operational characteristics are present at the same time.

The tests required herein are based upon the possibility that two or more light-types can be located within the FOV of an OFD at the same time. The test approach is to continually add a different light type to the previous tested group until the group contains a maximum "realistic" mix of possible lights. The individual lights selected in a group are representative of the many different types of lights which can be found in AF facilities, hangars, shelters, and other applications throughout the world. Table 2 lists the recommended test combinations of lights and shows their respective minimum distances from the OFD. Figure 13 shows the setup.

Step 1. The OFD and lights 1 and 2 (of Group A if specified by user in table 2) shall be mounted on fixtures at the same height (approximately 1.5 meters above the floor). The light shall be placed the distances from the OFD specified in table 2, directly facing the OFD. The configuration should be such that the lights and/or light grouping and the OFD have, as close as possible, the same center-line FOV axis.

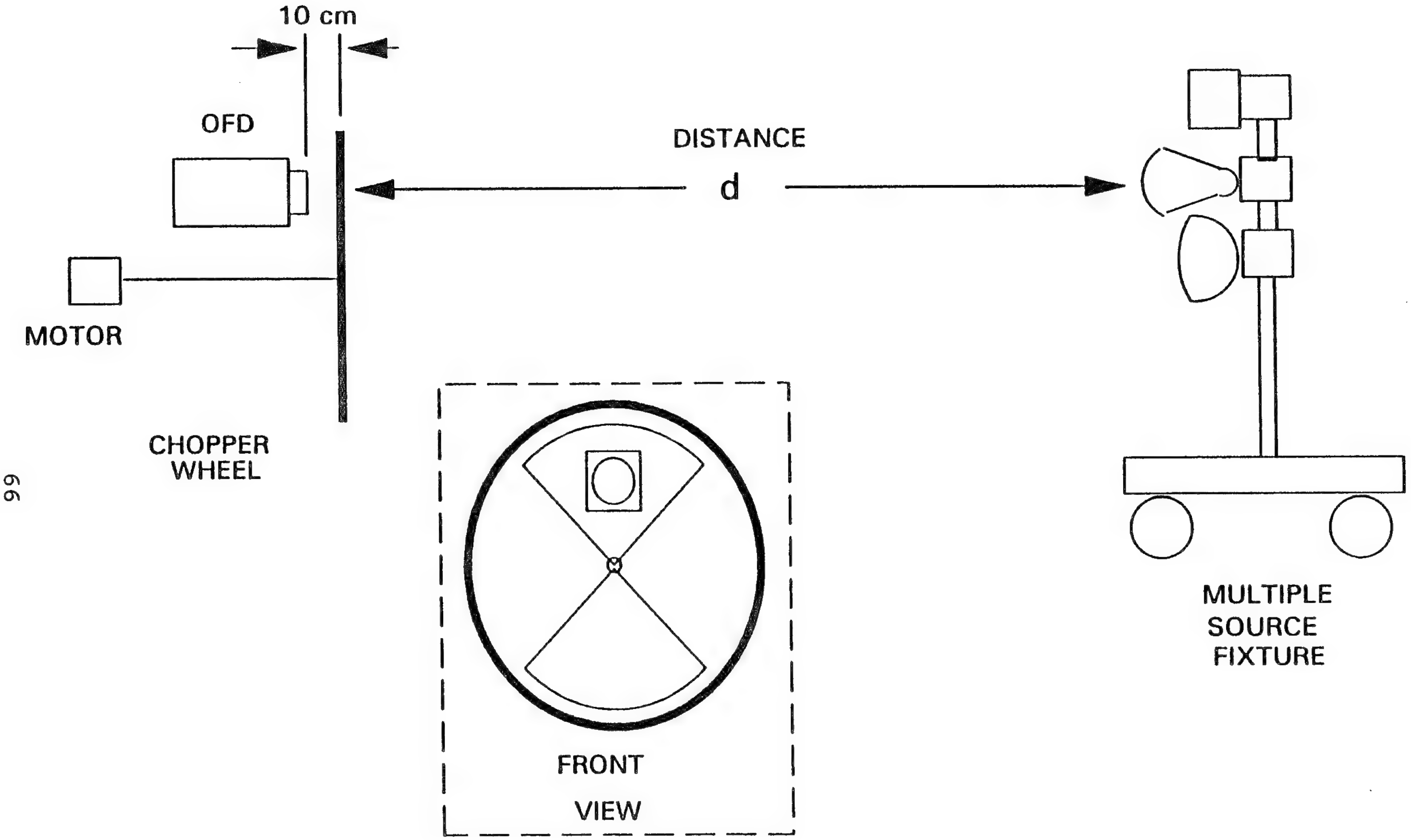


Figure 13, Refer 9.1.1.1.2
MULTIPLE LIGHTS AND GROUPINGS OF LIGHTS

Step 2. The OFD shall be turned on.

Step 3. After the OFD has been on for 30 minutes, lights 1 and 2 of Group A shall then be turned on.

Step 4. After lights 1 and 2 have been on for 30 minutes, the OFD shall then be turned on and off 5 consecutive times at intervals of 1 second.

Step 5. Immediately after step 4, turn the lights (at the same time) on and off 5 consecutive times at intervals of 5 minutes (on some lights such as the sodium vapor, there may be a longer "cool-down" time required before the lamp will restart).

Step 6. Immediately after step 5, rotate lights side-to-side (about 45 degrees per 2 seconds) 3 consecutive times.

Step 7. Maintaining the same configuration with lights and OFD still on, place the chopper apparatus described in paragraph 8.1.1.1.1 10 cm from the face of the OFD and operate it at the frequencies and times so stated.

Step 8. Maintain the same configuration as in step 1 and remove the glass lens covers of the lamps, if applicable. Take necessary safety precautions, including eye protection. Repeat steps 2-7.

Step 9. After completing step 8, replace glass plates on lamp and introduce light 3 (of Group A, if required/specified by user in table 2) into the configuration at the distance from the OFD stated in table 2. Conduct steps 2 through 8.

Step 10. After completing step 8 with lights 1, 2, and 3, and replacing their glass cover plates, where applicable, add light 4 to the configuration at the distance from the OFD stated in table 2. Conduct steps 2 through 8.

Step 11. Continue adding lights through the "nth" light included in Group A as indicated in table 2.

Step 12. Repeat steps 1-11 for the next Group B, and repeat for each group through Group "N", depending upon what is specified in table 2.

9.1.1.1.3 Combinations of different categories of sources of radiation stimuli. These tests include combinations of different categories of sources of radiation stimuli that may affect OFDs.

9.1.1.1.3.1 Multiple source emissions associated with AGE lightalls. In addition to the lamp emissions, lightall units also exhibit blackbody, broad-band infrared radiation from their diesel or JP-4 hot engine exhaust surfaces. The exhaust and engine hot surfaces are located in compartments near the middle of the units,

except for the M-60 A/M 32A-95 and D-500 hot-air generators/ compressor-gas turbines which also have exhaust ports on top of the units. The vertical exhaust from these units can extend to heights over 35 feet. These types of AGE units therefore, have two separate hot body locations. The units have been associated with many false alarms.

The compartment door is opened during operation, exposing the hot engine and exhaust surfaces. The areal extent of the hot exhaust surface is about 50 cm x 50 cm. Its temperature can range from about 300 degrees C (572 degrees F) to about 600 degrees C (1100 degrees F) depending upon the type of engine. Assume an emissivity of 0.95 for the surface materials. At this temperature range and emissivity, the maximum wavelength emissions in the blackbody "bell-shaped" curve will range from 3.3 micrometers to 5 micrometers.

Step 1. Mount the OFD 150 cm above the floor, with its center axis pointed horizontally at the center of the Phillips H33GL-400/DX 400 W mercury vapor lamp (NSN 6240-00-885-6852) with lens cover plate on. The lamp shall be mounted on a mobile fixture at the same height as the OFD. A two element electrical hot plate unit shall be mounted on the same mobile fixture 60 cm directly below the lamp and 90 cm above the floor. The fixture, with both hot plate unit and lamp should be positioned 180 cm (about 6 ft) from the OFD. The dual hot plate elements shall be pointed directly at the OFD.

Step 2. The lamp, hot plate unit, and OFD shall be turned on at the same time. The hot plates shall be gradually heated to the maximum temperature (about 650 degrees C or 1200 degrees F) and maintained at this temperature. After operating for 30 minutes, the OFD shall be switched on and off 5 times at intervals of 1 minute each. The OFD shall remain on and the lamp switched on and off 5 times at intervals of 5 minutes on, 5 minutes off. These tests shall be repeated twice. The OFD shall not produce a fire signal from the instant of receiving power through the entire test procedure.

Step 3. The above steps 1 and 2 shall be repeated with the lens cover plate removed from the lamp.

Step 4. The mounting fixture holding the lamp and hot plate shall then be moved to a distance of 2.4 meters (8 ft) from the OFD. The lens cover shall be reaffixed to the lamp. The light chopper apparatus discussed in paragraph 8.1.1.1.1 shall be located directly in front of the OFD. With the OFD operating, the hot plate and lamp shall be turned on. As the hot plate is gradually heating up to a maximum of about 650 degrees C, the chopper shall be operated at frequencies of 0.5-, 5-, 10-, and 20 Hz, respectively, for 10 seconds at each frequency setting. These tests shall be repeated once.

Step 5. After lamp and hot plate (now at 650 degrees C) have been on for 30 minutes, the chopper apparatus shall be operated at the frequencies and times stated in paragraph 8.1.1.1.1. This step shall be repeated once.

Step 6. The step 4 and 5 tests shall be repeated with lens cover removed from the 400 W mercury vapor lamp.

Step 7. The 400 W mercury vapor lamp shall be replaced with a 1000 W high pressure sodium vapor lamp (GE HLXG0151A17X7XX059) with lens cover on, and the entire sequence of above tests (steps 1-7) repeated.

Step 8. The above tests, steps 1-7, shall be repeated with lens cover plate removed from the sodium vapor lamp.

Step 9. The next lightall test involves the hot surfaces and two 1000 W multivapor metal halide lamps on the TF-1. The above 1000 W high pressure sodium lamp in step 7/8 shall be replaced with one 1000 W multivapor metal halide lamp (NSN 6240-01-012-0829) with lens cover on, mounted on the mounting fixture described in step 1. The lamp/hot plate fixture shall be located 4 meters (13 ft) from the OFD. The test procedures and format shall be exactly as stated above for the NF2 and NF2D lamps, except in this test the mobile fixture will remain at 4 meters distance during the chopped radiation test.

Step 10. Step 9 shall be repeated with the glass cover plate removed from the multivapor metal halide lamp.

During the entire sequence of tests, the OFD shall not produce a fire signal.

9.1.1.1.3.2 Complex multiple source test scenario #1 - operational hardened aircraft shelter. TAB V Series 1, 2 or 3 Hardened Aircraft Shelters (HAS) have various types of lamp configurations, and a large range of possible sources of OFD stimuli. The lamp configurations may include one or more of the following: (a) banks of 4-bulb, 48" length, 40 W fluorescent white bulbs, in white enamel reflecting fixtures; (b) 400 W mercury vapor lamps hanging down from curved wall at a uniform height of about 8-9 meters; (3) large 1000 W high pressure sodium vapor lamps, in swivel fixtures with glass plates. One or more of the mercury and/or sodium lamp glass cover plates may be cracked or missing. The fluorescent fixtures are located at heights of about 2 meters, 6 meters, and 9 meters on both sides of the curved wall structure. They are aligned in rows of about 4 fixtures spaced 2 meters apart.

In addition to one or more of the above types of lamps, other sources of OFD stimuli are present. These include radiative emissions from aircraft lights, engines, pods/subsystems, hot surfaces and lamps of AGE units, handheld lights, moving vehicle

lights, and possibly sunlight or reflected lightning from standing water on floor.

Assume the presence of an aircraft such as a F-15 or F-16 involved in an integrated combat turn (ICT) operation. Such an operation includes refueling, weapons transfer, wing tank exchanges, and several other general mission readiness functions. Security, fire, fuel, LOX, AGE support units, standby vehicles, and tools are present. Shelter doors either open or closed. Aircraft engine start, run-up through 80% power, and taxi out. Aircraft lights operating except IFR and landing lights. Hand held communications and HF-tail and HF-wing radios in operation. Other possible activities include minor tests of attack radar, navigation radar, terrain radar, and jammers. This multiple false alarm source scenario, therefore, includes radiation stimuli associated with several diverse sources.

The following series of test configurations are depicted in figure 13.

<u>Step 1.</u> A 400 W mercury vapor lamp and a two-bulb 40 W, 48" length, soft white fluorescent lamp fixture shall be located 3 meters from the OFD, aligned directly facing the OFD. Both OFD and lamps shall be at least 1 meter above the floor. After the OFD has been operating for 10 minutes, both the dual fluorescent and 400 W mercury vapor lamps shall be turned on.

<u>Step 2.</u> After 30 minutes both lamp types shall be turned on and off 5 times in intervals of 2 minutes on, 2 minutes off. The lights shall be left on and the OFD switched on and off 5 times in rapid succession (1 second).

<u>Step 3.</u> Maintaining the same configuration, with lights on as before, the chopper apparatus shall be placed close to the face of the OFD and operated at frequencies and times as described in paragraph 8.1.1.1.1.

<u>Step 4.</u> Repeat step 1 - 3 with the mercury vapor lamp glass cover plate removed.

<u>Step 5.</u> Remove the chopper apparatus from the above test configuration, replace the glass cover plate, and maintain the configuration of lights and OFD. Locate a 1000 W high pressure sodium vapor lamp, representing a lightall or side wall swivel-mounted lamp, adjacent to the other two light types, at the same height, and at the same distance from the OFD. The same procedures, as above, steps 1 - 3, shall be conducted, including the chopped light tests.

<u>Step 6.</u> Repeat steps 1 - 3 with the lens cover removed from the 1000 W high pressure sodium vapor lamp.

Step 7. Remove the chopper apparatus, turn off the OFD, replace the lens cover on the high pressure sodium lamp, and maintain the three-light configuration as in step 5 above. Locate a dual element hot plate adjacent to the latter light configuration, at the same height, and at the same distance from the OFD. The hot plate elements should directly face the OFD. The OFD and lights shall then be turned on. The temperature of the hot plates shall be raised in steps from ambient to 200 degrees C, 400 degrees C, and 650 degrees C (about the maximum hot plate temperature). The chopped radiation tests shall be conducted at each of these temperature levels at the frequencies and times described in 8.1.1.1.1. After the chopped radiation tests at each of these temperature levels, the OFD shall be turned on and off 5 times consecutively at 1 second intervals.

Step 8. Step 7 shall be repeated with the lens covers removed from both the sodium vapor and mercury vapor lamps.

Step 9. Replace the lens covers and maintain the latter lamp configuration in step 7. Move dual hot plate fixture to a distance of 7 meters from the OFD (the approximate distance in a TAB V Series 1 from an OFD looking normal to an aircraft engine's exhaust). Place the chopper apparatus 1 meter directly in front of the hot plate. Place the following aircraft lights along side the fluorescent and mercury lamps (3 meters from OFD): aircraft navigation (strobe) light (xxxxxx), IFR (in-flight refueling light, e.g. GE Lamp No. 4593), red navigation light, white navigation light, anti-collision light, and a landing light (e.g. 600 W, 600,000 candle power, GE Q4559, halogen Quartzline) or their equivalents. After the OFD has operated for 10 minutes, turn on all lights. After 30 minutes switch fluorescent, mercury, and sodium lights on and off 5 consecutive times, 10 minutes apart. With all lights on, switch OFD on and off 5 consecutive times, 1 second apart.

Step 10. In the same configuration as step 9, with all lights and OFD on, bring the dual hot plates from ambient room temperature to 650 degrees C. During the time the dual element hot plates are heating to maximum temperature, the chopper apparatus shall be operated at 10 Hz.

Step 11. Repeat step 10 procedure with lens cover removed from sodium lamp.

Step 12. On the mobile fixture described in 9.1.1.1.3.1, which has a two element hot plate unit mounted 90 cm above the floor, mount a 1000 W multivapor metal halide lamp without lens cover in the same location as the mobile fixture's lamp position (150 cm above the floor). Maintain the last test configuration (step 10) of light sources and dual hot plate unit. Maintain the dual hot plate temperature at 650 degrees C (maximum). Move the chopper apparatus 1 meter in front of the double hot plate and operate at a frequency

of 5 Hz. Locate the mobile fixture with multivapor metal halide lamp and single hot plate unit 3 meters to the side of the OFD, pointing 90 degrees to the OFD's center line-of-sight (see Figure xx). With all the above lights, hot plate unit, and chopper turned on, move the mobile fixture at a speed of about 30 cm/sec through the OFD's FOV to a distance 3 meters on the other side of the OFD. Turn mobile fixture around and repeat movement in the other direction. The addition of this test to the overall sequence of tests simulates the movement of a vehicle or AGE unit during an operational ICT.

Step 13. With all sources and devices in their same positions and operating in the same manner as during the mobile fixture test above in step 12, a 5 W handheld Walkie-Talkie unit, Motorola Saber, NS# 5820PH99QX/052H, or equivalent, shall be placed 10 cm (4") from the OFD unit and operated at full/max transmission power.

The above series of test steps simulates the following environments inside a hardened aircraft shelter during an operational ICT.

1. Exposure to two types of facility lights at the same time; with and without lens covers.

2. Power disruptions to the above lights and/or OFD.

3. Repetitive interference/chopping of lights within the FOV of the OFD.

4. The above lights with the addition of an intense lightall light source; with and without lens; addition of hot body; power disruptions; chopped radiation.

5. Addition of aircraft with engine operating at 80% - IR emission source & hot body; aircraft lights on; chopped.

6. Addition of moving vehicles with lights and hot exhaust surfaces.

7. Addition of electromagnetic radiation from communication devices, radar, and pods.

9.1.1.1.3.3 Complex multiple source test scenario #2 - typical aircraft maintenance hangar with doors open. In this scenario the mix of sources of possible OFD stimuli include facility lights, outside area/perimeter lights, AGE engine

exhausts, welding operations, personnel support items, and maintenance operations.

Assume a large maintenance hangar configuration, about 60 meters x 60 meters x 25 meters high, as is shown in Figure xx. This type of facility usually contains multiple-types of lighting. Assume the presence of 400 W mercury vapor lamps and 1000 W high pressure sodium vapor lamps with fast restart capability, arranged in alternating rows extending the length of the hangar, at 20 meters height, spaced 5 meters apart. Two 1500 W quartz halogen lamps are mounted 10 meters high above the floor on an upright steel beam in the center of the hangar. The lamps are mounted 90 degrees apart and pointed at a 45 degree angle to the floor. They are in the direct line-of-sight of OFDs mounted on the side walls, 30 meters distance, 2.5 meters above the floor (to provide "under-the-wing" fire detection). Rate-of-rise temperature sensors are located on the tresses above the lights.

Assume the hangar doors are fully open. Also, about 30 meters (98 ft) in the distance, but in the OFD's FOV outside the open doors, arc welding operations are being conducted on an aircraft scaffolding (steel plate, 6013 rod). A 15 meter-high light pole with 1000 W mercury xenon arc lamp used to illuminate the immediate outside area, is 50 meters from the OFD in its FOV and has a cracked or broken glass cover.

Assume the interior of the hangar contains an aircraft with scaffolding along side. On the scaffolding platforms, 2 meters and 4 meters above the floor, are 300 W quartz halogen lamps pointing toward the aircraft. Assume that the glass cover plate is missing on one of the 300 W workshop lamps. Also assume all facility lights are turned on with one or more overhead lamps without glass cover plates; a personnel 1500 W electrical floor heater unit in operation, located on scaffolding platform 2 meters high; and AGE M-60 AC power generator/air compressor close to aircraft.

The following test procedures are required.

Step 1. A 400 W mercury vapor lamp, a 1000 W high pressure sodium vapor lamp with quick restart capability, and a 1500 W quartz halogen lamp shall be mounted on fixtures such as the mobile fixture in step 1, paragraph 9.1.1.1.3.2. The lamp fixtures' glass cover plates shall be attached. The lights shall be located about 1.5 meters above the floor and separated by 1 meter.

Step 2. The OFD shall be mounted on another fixture at the same height as the lamps. The lamps shall be placed 4 meters directly in front of the OFD.

Step 3. A single element hot plate shall be located on a fixture 1.5 meters high. A second single element hot plate shall be mounted on the same fixture, directly below the latter hot plate,

about 60 cm high. Both hot plates shall be mounted such that their elements face the OFD. The "hot plate fixture" shall be placed 5 meters from the OFD.

Step 4. An ultraviolet source, such as a deuterium lamp, shall be located at a sufficient distance, and/or with appropriate filters if required, to provide an irradiance of 1×10^{-2} $\mu W/cm^2$ in the 200 nm - 260 nm wavelength band at the OFD (simulates afterburner at approximate distance of 0.5 Km); 4.5×10^{-5} microwatts/cm^2 simulates arc welding of steel plate at 50 meters; and an irradiance of about 70×10^{-4} microwatts/cm^2 represents the UV in the 200-260 nm band of the 1000 W mercury xenon lamp 50 meters from the OFD.

Step 5. The OFD shall be turned on. After a period of 10 minutes the mercury, sodium, and quartz lamps shall be turned on and left on for 15 minutes. The lamps shall then be switched on and off five times consecutively at intervals of 2 minutes on, 2 minutes off.

Step 6. With the lamps in step 5 on, turn on the ultraviolet source.

Step 7. After the UV source has been on for 5 minutes, turn on both hot plates to maximum temperature setting and allow to reach maximum temperature. Maintain this setting for 10 minutes and then switch OFD on and off 3 consecutive times at intervals of 2 minutes on and 2 minutes off.

Step 8. With all test fixture items and OFD operating, place the chopper apparatus in front of the OFD and operate as stated in paragraph 8.1.1.1.1. Remove the chopper apparatus.

Step 9. Maintain the distance between OFD and lamps as described in the above steps. With all lamps, UV source, and hot plates on, a "heat gun", such as a Black & Decker Heat 'N' Strip 9751 Type, shall be turned on and placed 0.5 meters in front of the OFD and 0.2 meters normal to the center line axis of the FOV (see Figure xx). This hot air will simulate the removal of the heat curing blanket from an aircraft after welding. The heat gun shall be held in this position for 2 minutes. It should not be pointed directly at the OFD's face.

Step 10. With the above mercury, sodium, and quartz light sources on, an arc welding apparatus should be set-up at a distance of 5 meters (98 ft) from the OFD. A steel plate welding operation using 6013 rod should be conducted for a period of 3 minutes. If this set-up is impractical, the UV emission should be simulated using a UV source such as a deuterium lamp. The irradiance in the band 190 nm - 260 nm at the OFD should be about 3.0×10^{-4} microwatts/cm^2.

9.1.1.1.3.4 Complex multiple source test scenario #3 - operational flow-through shelter . This scenario involves a small flow-through shelter which utilizes an array of 300 W Quartz-Tungsten-Halogen lamps located every 8 feet along the shelter, mounted 3 feet above the floor; the presence of a typical fighter aircraft, e.g. F-15; and a Aircraft Ground Equipment unit such as an air compressor/power cart or Hydraulic Test Stand, both having very hot exhaust pipes/assemblies.

This is one of the simplest scenarios to be found in an aircraft hangar or shelter. It involves hot bodies such as a vehicle's exhaust or an AGE exhaust manifold and engine, an aircraft engine nozzle (and perhaps its exhaust effluent), and a light source such as a 300 watt incandescent Quartz Tungsten Halogen lamp, both types of sources found routinely in Air Force flow-through shelters, hangars and maintenance docks. Assume that the detector is mounted either on the side wall, 10 feet above the floor to provide underwing coverage, or is located over the opening/door, in the center, at either end, and its center axis of its FOV pointed at a 45° angle to the floor.

Also assume the presence of a common piece of Aircraft Ground Equipment (AGE) such as a TTU 228/E Hydraulic Test Stand Unit. This unit has an inside exhaust pipe temperature in the 670° C (1238° F) range, and an exposed exhaust stack/pipe surface with a temperature of 367° C (694° F). Assume that this AGE item is located 20 feet or less from the detector, which would be normal in a small flow-through shelter or hangar such as a Hardened Aircraft Shelter TAB V. The irradiance of this "hot body" in the 4.4 micrometer band is such as to exceed the irradiance from a 2 foot x 2 foot JP-4 pan fire as far away as 100 feet.

Also, for purposes here, assume the Quartz Tungsten Halogen lamp is without its glass cover plate, and is 10 feet away from the detector, located on an adjacent wall near the opening of the hangar in the FOV of the detector (note that 1000 watt lamps of this type are sometimes used in large maintenance hangars and 4000 watt versions are often used for internal facility photography). Broken glass cover plates on lamp fixtures is not rare and in some facilities lamp fixtures may be without their glass cover plates.

Because it is impractical to locate a TTU 228/E Hydraulic Test Stand AGE unit in the lab, a simple 1000 W hot plate can be used for simulation. A single element 1000 W hot plate at full power will reach about 700° F, about half the temperature of the AGE interior exhaust pipe and about the same as the exhaust pipe surface. Also, its areal extent is about half of that of the AGE exhaust surface. At 10 feet distance, this hot plate has about the same irradiance in the 4.4 micrometer band as does the 1238° F AGE unit at 15-20 feet. Therefore, the simulator hot plate should be located at 10 feet distance, along with the 300 W lamp, for this

representative test.

Step 1. The first step in the sample procedure is to turn on the detector and let is warm up for a few minutes to verify that it is working properly. After 10 minutes, turn-on the 1000 watt hot plate at maximum. After 10 minutes at maximum temperature, observe the response of the detector.

Step 2. The second step is to "chop" the IR-emitted radiation from the hot plate with a "chopper blade" apparatus such as the fan-wheel device described earlier, at speeds of 1 Hz to 20 Hz. This duplicates several people walking in between the hot plate and detector, a floor fan, an irregularly shaped vehicle passing through the FOV, or a person waving his arm in front of either the detector or hot plate. Observe the response of the detector.

Step 3. The third step is to remove the hot plate or let it cool down to room temperature and then turn on the Quartz Tungsten Halogen lamp with the glass cover plate on. Observe the response of the detector. After 15 minutes turn lamp on and off at 10 second intervals, 5 times. Observe the response of the detector.

Step 4. The fourth step is to chop the radiation from the lamp by the same means as above, either by waving an object back and forth through the FOV close to the lamp or with the use of a chopper apparatus/fan.

Step 5. The fifth step is to turn the hot plate back on and let it reach maximum temperature. Ten minutes after it has reached maximum temperature, turn on the lamp. Observe the response of the detector over the next 10 minutes.

Step 6. The sixth step is to chop the hot plate's emission with the lamp remaining on and not chopped. Observe the response of the detector. Turn off the lamp. While the hot plate is being chopped, switch on the lamp. Observe the response of the detector.

Step 7. The seventh step is to stop chopping the hot plate and chop only the lamp. Observe the response of the detector. With this lamp chopping in progress, move the hot plate slowing away from the detector at about 1'/sec to a distance of 20 feet from the detector; then bring it toward to detector at the same rate until it is only 5' from the detector. The lamp is not to be moved during this process.

Step 8. The eighth step is to chop both sources with the chopper apparatus at the detector so that the entire FOV is chopped. Observe the response of the detector.

Step 9. Conduct all the steps above with the Quartz Tungsten Halogen glass plate cover removed.

Step 10. Instead of conducting steps 1 and 2 first, conduct steps 3 and 4 first with the UV lamp source; then conduct steps 1 and 2 with the hot plate. Note that some detectors are keyed to respond first to one or the other of the UV or IR signals, then the other wavelength sensor is required to respond in the detection logic.

Step 11. Repeat these test twice.

The detector shall not alarm during any of these tests.

9.1.1.1.3.4 Complex multiple source test scenario #4 - large aircraft hangar with photographic session.

This scenario involves a large hangar with a photographic session. In a large facility the background is dark and the subject requires direct illumination. Large wattage flood lamps are typically used, such as a 4000 W Quartz Tungsten Halogen lamps and high wattage strobes such as a 2000 W-sec Norman Strobe.

In this scenario, two 1 kw hot plates will be used, side-by-side to simulate the area extent and irradiance of an AGE unit's exhaust structure; a 1500 W metal halide lamp used for area lighting; a simple flashlight; and two photographic lights.

Step 1. The 1500 W halide lamp, with glass cover plate on, shall be mounted on a fixture at 1.5 meter height, the same height as the detector, which is mounted on a separate fixture. The 1500 W lamp fixture is to be located 10 meters from the detector.

The 4000 W flood and 2000 W-sec strobe are to be mounted on a separate fixture at 1.5 meters height. This fixture is to located 5 meters from the detector, pointed directly at the face of the detector.

The dual hot plate, two units side-by-side, shall be mounted also 1.5 meters high on a separate fixture located 6 meters from the detector.

Step 2. After the detector has been on for 15 minutes, turn on the halide lamp and leave on for the duration of the tests. Also turn on the hot plates.

Step 3. After the above items have been on for 10 minutes, turn on the 4000 W flood lamp. After 10 minutes, also operate the strobe at its maximum flash frequency.

Step 4. Turn off the strobe and chop the flood lamp with the chopper apparatus as specified in Paragraph 8.1.1.1.1.

Step 5. Stop the flood lamp chopping and chop the dual hot plates by locating the chopper apparatus about 1 meter in front of them. Continue this hot plate chopping for 5 minutes at a variable rate

between 1 Hz and 10 Hz.

Step 6. While the above chopping is in progress, hold a flashlight with the plain lens covering 10 cm from the face of the OFD. Hold for 1 minute, then move flashlight side to side in rapid succession.

Step 7. Repeat these steps twice.

The detector shall not alarm during any of these tests.

9.1.1.1.3.5 Other Multiple Source Scenarios. The purchasing and/or user agency may specify other combinations of sources and their respective movements, modulations, and operations in both time and space. Should such additional tests be required, they will be delineated under this paragraph number.

10.0 ABILITY TO DETECT FIRE IN PRESENCE OF FALSE ALARM SOURCES

As a final test, the detector should be required to also identify the specified type and size fire at the required maximum distance in the required time. The user agency or procurement agency shall specify how this is to be accomplished during one or several of the above test procedures.